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J. B. MACKINTOSH, E.M., C.E.
A. L. BEEBE, PH.B.
S. S. FOWLER, A.B.
D. E. MORAN.
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J. K. REES, A.M., E.M. J. B. MACINTOSH, E.M., C.E.
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For the Engineering Society.

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THE STUDY OF CHEMISTRY IN GERMANY.

BY SPENCER BAIRD NEWBERRY, PH. D.

GERMANY is to-day preëminently the home of chemistry. Though other nations may with equal right claim the credit of having laid the foundations of the science, Germany has of late years far outstripped all rivals in the number and importance of her contributions to it, and also in facilities for advanced instruction. In America, and perhaps to a still more marked degree in England, a certain time spent in study under some one of the most distinguished German teachers has come to be considered an almost indispensable preparation for those who propose to become themselves teachers of theoretical chemistry, or to engage in original scientific research. But little has been written, however, to aid students in making an intelligent choice among the many universities and scientific schools of Germany, and it may be that the following sketch of the methods of instruction in chemistry there followed will be of assistance to those who have in view a European trip with a similar object.

In the first place, it is hardly worth while for an American to go abroad to study the practical applications of chemistry. There are no better technical schools anywhere than our own. If the student's object be to make himself an expert analytical or industrial chemist, a metallurgist or an assayer, a course of

study in any one of our best equipped scientific schools will be far more certain to make him master of simple, rapid methods, adapted to the peculiar conditions of our own industries, than any training to be obtained abroad. But if his interest be in pure science, his object to study the best methods of instruction and investigation, a year or two of laboratory practice and attendance upon lectures in a German university will open to him wholly new fields of thought and research. There is much in every science that cannot be learned from books; the best of them are years behind the ever-advancing thought of their originators. The true measure of the present stage of scientific progress is to be sought in the minds of the ablest investigators; not in that which is already proved, but rather in that which is as yet but dimly foreshadowed. The privilege of personal contact with men of eminence—of even sharing in their researches—is, in fact, the great benefit to be derived from the study of science in Germany.

A discussion of the points in which German universities differ from our own would be foreign to the purpose of this article. For information on this subject, as well as for an explanation of the complicated system of matriculation and graduation, special faculties, rank of professors, university discipline, etc., I cannot do better than to refer the reader to Mr. James M. Hart's excellent book, "German Universities." It is sufficient for my present purpose to state that in Germany there is no prescribed course of study. The student is free to attend any courses of lectures he may select, simply upon the payment of a prescribed sum for each course. For example, in Berlin, the price of a course of lectures of three to five hours per week for one *semester*, or term of one-half year, is about ten dollars. For laboratory instruction the price is twenty-five dollars per term. At the beginning of each university year, a complete list of lecturers, with their subjects and hours, is published, and from this the student selects such courses of lectures as he desires to hear. The only restriction put upon this liberty of choice is in the requirement for the final examination. In Berlin, no student is allowed to present himself as a candidate for the degree of Doctor of Philosophy, until he has completed three years' attendance upon lectures in the university; he must be prepared to undergo severe oral examinations in five subjects, viz.: One chief subject (upon which a thesis is required), two subordinate subjects, Latin, and the history of philosophy,

Most other universities are, however, much less severe in this respect; generally foreigners are admitted to examination as soon as they consider themselves prepared, and knowledge of Latin and philosophy is taken for granted. Most American students, to whom the degree is often of secondary importance, prefer to devote themselves wholly to some one special study, rather than to burden themselves with the additional work necessary to prepare them for examination.

But few students, German or foreign, complete their whole university course at one institution. There are no classes, as we understand the word; the students are not graded in any respect, and hence the system of transfer from one university to another is exceedingly simple. The student has only to obtain a certificate of honorable dismissal from one institution, and upon presentation of this he is admitted to full and regular standing in another, without further formalities.

Among the German universities which offer special advantages for the study of chemistry, those of Berlin, Leipzig, Göttingen, Bonn, Tübingen, and Heidelberg are most frequented by foreign students. The general plan of instruction is the same in all; lectures on general chemistry extend through the entire year, and differ from those given in American colleges only in being more advanced (since German students have already received in the *gymnasium* thorough training in elementary chemistry), and also in being generally far more profusely illustrated by experiments. Often two or more professors lecture in competition upon the same subject; a system of rivalry which stimulates each to the highest zeal, as a lecturer's income and renown depend largely upon the number of his hearers.

In addition to the lectures on general chemistry, courses on different technical branches are given, while some members of the faculty confine themselves to "special chapters" of organic or inorganic chemistry for which their own investigations have especially qualified them. Thus the student finds in the synopsis of lectures for the year a list of perhaps a dozen distinct courses, from which he is free to select such as will be of assistance to him in the line he proposes to follow.

In laboratory work, as in lectures, there is no prescribed course of study. The student commences with inorganic analysis, qualitative and quantitative, upon which he may spend as much time as he desires; but in no case, I think,

even in special technical schools, is so much attention given to rapid methods for the complete analysis of commercial products as in some American laboratories.

After a certain amount of inorganic work the student is admitted to the organic laboratory, and here, generally, begins his personal association with teachers of note, and his career as an investigator. After a few weeks of practice in combustion analysis and the methods of manipulation peculiar to organic chemistry, each student is assigned some problem involving experiment and observation, in the solution of which he is associated with the professor in charge, or with one of his assistants. If the investigation is successful, the results are published in the scientific journals as the joint work of instructor and student. In this system of partnership, the teacher's share consists in the original plan of the line of research, and in constant supervision and frequent suggestions during the progress of the work, while the actual manipulations fall to the lot of the student. The latter is at any time free to begin an independent investigation, following out ideas of his own, and in this also he may be sure of constant advice and assistance from the professor in his daily round. Students often retain in this way for years a more or less definite connection with the university, awaiting in the meantime a possible opening as assistant in the laboratory or chemist to some manufacturing establishment. Such places are eagerly sought, though but poorly paid, for the competition in the line of chemistry is enormous. State examinations are held from time to time, through which a limited number of successful candidates receive appointments under the government, or are provided with diplomas which open the way to other responsible and even lucrative positions.

In the long list of German universities, that of Berlin holds the first place in the number of its students (nearly 6,000), and probably also in the renown of its faculty. The department of chemistry has long been famous, and has at its head perhaps the first of living German chemists, Professor A. W. Hofmann. The laboratory, a large fire-proof brick building in the *Georgenstrasse*, contains lecture-rooms, qualitative, quantitative, organic and special laboratories, library, etc. Professor Hofmann lectures daily, except Saturday, from 9 to 11 A.M., to a class of nearly four hundred students; in the winter term on inorganic, in the summer term on organic chemistry.

These lectures are illustrated by a most elaborate series of experiments, among them the well-known Hofmann's experiments showing the combination of gases in definite volume-proportions.

In the laboratory a large amount of space is given up to organic chemistry, and most of the investigations carried on are in the line of the aromatic series. Professor Hofmann's investigations on the aniline colors are perhaps the most widely known of his contributions to science, and many of his assistants and students are at present working in the same fertile field. The Berlin laboratory is the headquarters of the German Chemical Society, and the regular fortnightly meetings are of the highest interest from the great number of valuable papers presented. These papers, with a synopsis of work elsewhere reported, constitute the *Berichte der Deutschen Chemischen Gessellschaft*, now probably the most important journal of chemistry published.

Among the many other well-known names which appear upon the list of the chemical faculty at Berlin may be mentioned the following: Liebermann, organic chemistry; Sell, history of chemistry and chemical analysis; Pinner, general chemistry and pharmacy. In the department of physics, the names of Helmholtz and Kirchoff are of world-wide fame.

The Berlin Mining School (*Berg-Akademie*), is also an admirable institution, and though comparatively distant from mines and metallurgical centres, has of late rivalled the celebrated school at Freiberg in number of students. Kerl in metallurgy, and Weiss in mineralogy, are the leading members of the faculty.

The Academy at Freiberg, Saxony, is essentially a school of mining and metallurgy, and as such is probably the first in Germany. The value of the course in fitting students for American practice may be questioned, and need not be here discussed. The institution certainly can boast a most able corps of teachers, fine collections, and, from its situation in the midst of mines and metallurgical works, unequalled facilities for illustration and practice.

The university at Bonn, on the Rhine, has an admirably equipped laboratory, and a strong faculty of chemistry, with the illustrious Kekulé at its head. Here, as in most German laboratories, the example of the professors tends to lead

advanced students to devote themselves to investigation in organic chemistry.

At Heidelberg, under Bunsen, work of a somewhat different character is carried on, for the tendency is rather toward original research in the lines which Prof. Bunsen has himself created; for example, gas analysis, spectrum analysis, the study of the organic compounds of arsenic and antimony, etc. Although the laboratories are far inferior to those of Bonn or Berlin, the reputation of Bunsen's achievements in science, and of his famous lectures, draws to Heidelberg a great number of foreign students. The faculty includes other well-known chemists; among them Kopp, author of important works on theoretical and historical chemistry.

Göttingen, once one of the first of German universities, has unquestionably declined of late years; the chemical department suffered a great loss in the death of Wöhler in September of last year.

It would require more space than I dare claim, merely to mention the numerous other laboratories of Germany, or the well-known men who have charge of them. Kolbe at Leipzig, Fittig and Hoppe-Seyler at Strassburg, Fehling at Stuttgart, Lothar Meyer at Tübingen, are all distinguished chemists, whose fame draws many foreign students to their laboratories. There can be no question that at any of the places above enumerated a kind of advanced training may be obtained, for which our American colleges, with perhaps the exception of Johns Hopkins University, have as yet made little provision; namely, the development of the faculties of observation and research. This constitutes, in fact, the chief advantage to be derived from the study of natural science in Germany. The spirit of investigation, the love of science for its own sake, pervades the whole army of German experimenters, as the scientific periodicals, filled to overflowing from month to month with the results of original work, abundantly show. This tendency is doubtless largely attributable to the small encouragement given to work in a practical direction by the present condition of German manufacturing interests, but it has been of incalculable benefit to the cause of science.

To the average American student, there is every inducement but the consideration of expense to spend at least a portion of the time at his disposal at Berlin. Though the fees for lectures and laboratory work are about the same as at other

universities, the cost of living in Berlin is considerably higher than in other German cities or towns. The difference in expense is, however, abundantly compensated by the special advantages for scientific work which the library, laboratories and collections of the university afford, and by the admirable museums, art galleries, concerts and theatres of the German capital. In the best *pensions*, or boarding houses, the cost of room and board is from thirty to forty dollars per month. Living at a restaurant is cheaper, and, on the whole, better; but on the other hand the *pension* affords excellent opportunities for practice in the language. The other expenses of the student are generally much less than in America. Books and apparatus cost from one-third to one-half as much as with us; clothing, of English goods and made by the best tailors, about two-thirds as much. From $800 to $1,000 a year will doubtless be found sufficient to enable the student to live liberally, even in Berlin, and should leave a comfortable margin for travelling during the vacations. Probably by far the larger number of German students spend less than half the latter sum, and among them the student of limited means need have no fear that even the most rigid economy will bring him into contempt.

One word in closing, on personal relations with fellow-students and professors. The Germans are preëminently a social people, and there is no country in Europe where a foreign student can be more sure of hearty welcome and civil treatment. The graduate of an American college will naturally be thrown more into contact with older and more advanced students, and it will be his own fault if he fails to form some cordial and lasting friendships among his companions in the laboratory or lecture-room. There are certain time-honored forms of courtesy, such as the morning greeting to neighboring students right and left, the "*Mahlzeit*" at the dinner-hour, both departing and returning, which from our practical and time-saving point of view seem superfluous; but there is a certain charm in these graces of manner, and their study and observance will be well repaid. Professors and instructors are accustomed to receive many marks of respect and deference from those under their charge; but respond with unfailing cordiality to every sign of interest on the part of the student. They seem, as a rule, to be favorably disposed toward Americans, doubtless on account of the admirable work which some

of our countrymen, now distinguished at home, have done under their guidance.

There is one feature of German university life against which it is impossible to speak too strongly. I refer to the student *Corps*. Those who make up these organizations are for the most part the idlers of the university, and no advantage to wisdom or manners is to be gained by associating with them. Probably the most contemptible spectacle a German university town affords is that of the beer-consuming, duel-fighting American student. Such a man throws aside all that is good in the most complete educational system in the world, and embraces only the senseless remnant of the customs of a past and barbarous age.

THE PRESENT ASPECT OF ORE-DRESSING IN EUROPE.

(*Continued from Vol. IV., p.* 322.)

By W. B. KUNHARDT, E.M.

Slime Washing.—The important operation of washing sorted slime classes for the purpose of separating the mineral from the gangue and producing final "concentrates," is performed on jigs, buddles, tables and sundry special machines. There still exists considerable difference of opinion regarding the relative merits of these apparatus for treating different kinds of material, and practice, therefore, presents analogous divergences. A few words upon each type of machine followed by a brief consideration of some comparative tests, and of the effects produced by change of apparatus in some of the mills may serve to indicate the salient features of present practice.

Jigs.—The process of jigging has been described as the sorting of equal-falling grains in intermittent rising currents of water. To understand the separating action of the jig upon classes of ore that have already been sorted in hydraulic classifiers into equal-falling grains, it is necessary to examine more closely into the laws of the free movement of bodies in water. These laws, formulated by *Sparre* and *Von dem Borne* thirty years ago, establish the following facts:

1. Grains of two different minerals whose diameters bear

an inverse ratio to their specific gravities, the specific gravity of water being deducted from each, fall through quiet water or through a continuous rising current with a motion which at first is accelerated, but they soon attain an equal maximum, and practically constant velocity.[1] During the first, short period of varied motion, the smaller, specifically heavier mineral moves faster than the larger, absolutely heavier body. The separation by jigging of "equal-falling grains" (using this term now in a limited sense to designate grains attaining the same constant maximum falling velocity) depends on the cumulative effects of the small gains made by the smaller mineral particles in the beginning of each short fall to which they are exposed on the jig. This action, exerted upon equal-falling grains, resolves jigging virtually into a hydraulic sizing; when carried into effect on unsorted ore it will suffice to separate two minerals of widely different sizes, and this has been the basis of the process of hand jigging without preparatory screen sizing which is still used in Cornwall and Flintshire.[2] The hydraulic sizing of unclassified, or even hydraulically sorted grains upon a jig is never as quick and economical an operation as the hydraulic sorting of screen-sized grains upon the same machine. Continental practice, therefore, restricts this first named mode of treatment to ore which is too small to be economically sized by screening.

2. Of two grains which rise in an ascending current and attain the same constant velocity, the smaller (specifically heavier) body will move the faster during a small fraction of the first second. This action may seem an anomaly when it is considered that according to the first law the same smaller particle would also fall faster than the larger one through a weaker rising current, but the explanation of the relative motions is to be found in the inertia of the larger body; of two equal-falling grains of quartz and galena in a continuous current, the former body has twenty-three times the mass and

[1] Von Sparre, *Zur Theorie der Separation*, p. 8. The period of accelerated motion is one second for particles 16 mm. ($\frac{5}{8}$ inch) in diameter, and 0.25 second for those 1 mm. ($\frac{1}{25}$ inch) in diameter.

[2] Experiments that have been worked into diagram form by *Althans* (Judges' Reports, Centennial Exhibition, 1876, Group 1, p. 222) make it appear that galena grains could be separated by jigging from grains of quartz 38 times the diameter of the galena, if the jig stroke were reduced to 2.5 mm., and the duration of the stroke to $\frac{1}{40}$ of a second, though the ratio of the specific gravities of these grains, after deducting the specific gravity of water from each, is only as 4.06 : 1.

absolute weight of the latter, and hence from its greater inertia it is slower to yield to the forces which are suddenly brought to bear upon it. This explanation also applies to the initial action of a descending current upon falling bodies, as developed by Rittinger[1] and stated below.

3. In a descending water current, the smaller of two bodies of the same specific gravity falls the faster for a fraction of the first second, and is then rapidly overtaken by the larger body. Of two equal sized bodies moving in a downward flow of water, the specifically lighter will fall the faster if the current descend with a high velocity—*e. g.*, at the rate of 1 meter per second; but with a low current velocity the movement of the specifically heavier body is, in the beginning, the faster. In the latter case, however, the difference between the falling velocities of the specifically heavier and lighter bodies in the first short period of fall is not as great as the similar difference occurring when the bodies move through quiet water or a rising current. Under all circumstances, therefore, a descending current is a disadvantage in the jigging of *equal sized* grains. Of two equal falling bodies, grouped together as such in a slime classifier, the smaller (hence specifically heavier) body falls, in the beginning, faster than the larger body in a downward current of water, and its advance over the slower moving body is greater than the similar advance made in quiet water. A descending current is therefore favorable to the jigging of *equal-falling* grains, and in this fact an explanation may, no doubt, be found why experiments made with slow-return movements on fine jigs (that frequently treat "equal-falling" ore classes), have from time to time been reported as failures. A jig for separating the different grains of a hydraulically sorted ore class works best with a regular piston motion; a quick return would promote a descending current and in so far be advantageous, but opposed to its introduction is the practical difficulty that it would tend to pack the ore upon the sieves.

The various equal-falling products of hydraulic sand, and coarse meal, classifiers are often treated on four and five sieve jigs; no rigid size limitation can be given for these products—the range is from 1.5 m. down to about 0.5 m. (the 'mineral' being necessarily much finer). The machines have been described, with a few notes upon their running and their capacity,

[1] Rittinger, *Aufbereitungskunde*, 1st Supplement, p. 33.

under the general subject of jigging. The maximum capacity of 8–10 tons per day, given for a meal jig, is only attained under the most favorable circumstances. In ordinary work, especially if the gangue contain any spathic iron, the machine will not treat over 6 tons in twenty-four hours. The stay-box commonly placed at the discharge end of a fine jig has frequently the shape of a small pyramidal funnel, and serves as a rough classifier; the fine tailing sands which pass through the neck of the funnel are washed on tables, while the overflow goes to waste or is used as wash water.

Buddles.—The hutches and pits in which the deposits formed in the extensive labyrinths of the old time mill were formerly hand-buddled by stirring and brooming, are now found only in isolated cases in any well-ordered dressing works. The Cornish round buddle, in which hand brooming is replaced by the action of mechanical revolving sweeps, is still the principal slime washer used in English tin mining regions, but on the continent it has made way for continuous working machines. The action upon the slimes is not very different to that produced in the Cornish classifying strips, the products from which are usually received by the buddle for further treatment. The separation must in this case, therefore, be a very poor one. The slime flows from the centre to the circumference of the buddle, or the reverse, depositing the ore in an annular pit, while the overflow passes through a tail gate. The revolving sweeps act with most effect upon the coarser particles of depositing material, stirring them repeatedly from their positions and causing them to roll on toward the tail part of the ring; in this way a very imperfect and oft to be repeated sizing is effected. The deposit which accumulates in twenty-four hours to a depth of 14–20 inches in the buddle is divided, according to color, into "heads, fore-krazers, hind-krazers, and tailings"; the number of times that each of these products is re-washed depends on the richness of the material and the size of the mill. The ore, with 2½–3 per cent. of tin oxide, is dressed in the largest works up to 86–96 per cent. of mineral. In order to effect this concentration the richest stuff that settles, after stamping, in the classifying strips is buddled three times and tossed in keeves three to six times—making six or nine washings in all, while the poorest product from the strips is subjected to at least thirty successive washing operations. An immense amount of labor is incurred.

Of the mineral contained in the ore, 93–94 per cent. is saved in the best mills, and 3 pounds of tin oxide per ton (of 2,240 pds. dry weight) goes to waste in the tailings.[1] These tailings are concentrated in large catch-pits and washed over and over again by small independent "stream works," which are built all along the river banks from the mines to the sea, and are said to work with profit on slimes carrying only 1 pound of tin oxide per ton. Results which are fully as good as those above given can be obtained on continuous machines with much less handling and washing of the ore. Considering the number of repeated washing operations the percentage of saving, high as it is, cannot be regarded as satisfactory. Upon close examination it appears that much of the loss is due to float mineral which is produced by the frequent drying and subsequent dilutions of the slimes. Notwithstanding such unfavorable evidence, the round, deep buddle, which is the material exponent of the local axiom that "tin settles best on tin," is adhered to with characteristic pertinacity. Some experiments made in the region with continuous washers have been unsuccessful, either because of defects in the machines or in the mode of running them, and such failures have been assigned as reasons for retaining the buddle. A depressed tin market and the impoverishment of many of the mines do not encourage capital to invest in new machines; and, moreover, the introduction of any mechanical washers that require an efficient transmission of power and a good protecting covering would necessitate an entire reconstruction of most of the mill structures, for their present condition is most dilapidated. Any system of dressing by which it is possible for subordinates in the regular mills to be pecuniarily interested in such enterprises as the "stream works" will always find some advocates whose motives do not bear close inspection. At West Seton, Cornwall, a Frue vanner has been used experimentally to wash the tin ore; the concentration was considered quite satisfactory, and was, of course, much more quickly effected than it would have been if performed by the old methods, but the cost of an extensive plant prevented the adoption of the machine.

Stationary Plane Tables.—In a class of hydraulically sorted, equal-falling grains, the diameters of the different minerals are, in practice, approximately in inverse proportion to their specific gravities after deducting the specific gravity of

[1] The loss not unfrequently rises to 6 pounds of "tin" per ton.

water from each. The separation of the different minerals of such a class of grains is effected on a stationary plane table by spreading the material upon it in a thin sheet of slime; the different mineral particles which, in rolling over the table surface with a certain constant velocity of the slime flow, will form a deposit upon it, have diameters that are inversely proportional to the squares of their specific gravities after deducting the specific gravity of water from each.[1] Grains whose diameters differ inversely as their specific gravities (each minus 1) are therefore separated into two or more groups with diameters inversely proportional to the squares of their specific gravities (each minus 1), and consequently the practical effect of the operation is a sizing. The fine, specifically heavy particles settle on the table, while the coarse, specifically lighter ones are carried off. The importance ascribed by Rittinger to an increasing force and velocity of the thin sheet of flowing water at increasing heights above the table surface does not seem to be generally conceded. Investigation has shown that by far the most important element which interferes with sizing on the washing table is an undue rapidity of the water current; the mineral particles, caught by a strong current and held partly in suspension, move by *sliding* instead of *rolling*, and are quickly carried into the tailings. To prevent this action as far as possible, the slimes are allowed to flow over the tables at very low velocity, and a portion of the gangue deposits with the mineral; then, by brooming, or by a current of clear water, or both, a second sizing is performed. This cleaning or "washing" process is repeated one or more times so as to produce headings of sufficient purity; the middle products, washed off the table in the successive operations, are re-treated, while the tailings obtained in the first separation go to waste.

The old intermittent table worked with brooms by manual labor is still found in some of the mountain districts where labor is very cheap, but even in those regions it is gradually being replaced by continuous apparatus.

An automatic plane table, known as a "frame," is used in England for concentrating very dilute slime. The stuff is allowed to flow upon the inclined table and all the overflow passes at once into a tail launder; wash-water is charged intermittently upon the depositing material from two troughs,

[1] Sparre, *Zur Theorie der Separation*, p. 28.

one set at the head, and the other over the middle of the table; clap-boards are opened at the same time and the washings are collected in two launders as heads and middlings of very low grade. The intermittent delivery of the wash-water and the opening of the clap-boards is very simply effected by a small continuous stream of water which fills little buckets that are attached by levers to the wash-water troughs; when one bucket is full, its weight tips the nearly balanced trough, which is thereby discharged, as is also the bucket itself; immediately a second bucket begins to fill, and soon brings the trough back to its first position, in which it is replenished. The clap-boards are moved by rods connecting them with the troughs. One boy attends to the proper working of two hundred automatic frames.

Tables spread with coarse linen cloths are occasionally used for the separation of gold from copper or lead minerals, but they too are being replaced by continuous machines in the few large works where such separations are made.

Continuous Round Tables.—The most commonly applied form of continuous slime washer for treating sorted fine meal and pulp, is the round table. Its separating action is the same as that of the plane table, but as the velocities of the slime and wash-water currents vary in flowing over the round tables, the character of the depositing material is additionally influenced by the law that the diameters of two particles of the same specific gravity deposited in shallow currents of different velocities are directly proportional to the fourth roots of those velocities.[1] Hence the slower the flow of water the finer will be the deposited mineral.

The ordinary rotating outward-flow table consists of a flat cone with a dip of approximately 5°–10° (from 1 : 12 to 1 : 6), and a diameter of 3.5 to 5.5 m. (11.5–23 ft.). The table surface is made of pine or beech, or, preferably, of narrow maple boards, secured to an iron frame of radial arms, 8–16 in number, set into a vertical rotating iron axle. At the centre or head of the table is a small fixed apron upon which the sorted ore-slime is continuously delivered from a launder. The slime is allowed to spread over fully one-third of this circular apron, and falls from its perimeter in a thin sheet upon the rotating table, with but very slight initial velocity. The slime covers at one time a sector of about two-fifths of the table, and the

[1] Sparre, *Zur Theorie der Separation*, p. 28.

overflow from the lower edge of this sector is received in the corresponding segment of a fixed circular launder, which communicates with the waste tailing system. The deposit left by the slime upon the table is moved around by the rotation of the machine, and brought under the action of a current of water which is delivered, like the original slime, to a part of the fixed apron, and thence spreads over the deposited material. The portion of stuff which the water washes off the table into a second section of the launder, reaching around one-third to two-fifths of the table circumference, forms a poor middle product; a rich middle product (sometimes constituting a second quality heading), is frequently carried by the wash-water to the lower part of the table, where, owing to the decreasing force of the current, which is there spread over a large area, the material is again deposited. A special water-pipe or small trough suspended over that portion of the table where these rich middlings begin to settle, delivers wash-water upon the machine to carry this product into its proper segment of circular receiving launder. Finally, nothing but the mineral headings remain where the slime was originally charged; this product is removed by strong water-jets or by brushes aided with a little water. The jets alone consume much water (which always implies large settling tanks and increased difficulty in preventing losses), and they leave an impalpable, slimy coating on the table, necessitating an occasional cleansing of the washing surface with pumice. The brush which wears best and requires very little motive power is made of bristles set on a long rotating radial axle, which is placed parallel with the incline of the table. It is often an advantage to protect from the action of any wash-water the richest headings which deposit on the table; hence in a few mills the wash-water, instead of being delivered upon the rotating surface from a fixed central apron, issues from holes in a spiral pipe which is suspended above the table and so curved that the best mineral headings are left untouched by the clear water.[1]

[1] This principle is carried still further with great advantage in the Evan's patent apron with spiral perimeter, which is in common use throughout the Lake Superior copper region. The deposited headings at any one point on the round table are protected from the flow of fresh slime (as well as of wash-water) by their passing at once beneath the apron. A rapid charging of the slimes is made possible without loss in the headings, so that a large table washing a very fine slime of native copper with a siliceous gangue treats 30 tons in twenty-four hours, producing at the same time tailings carrying 0.75% copper.

The proportion of intermediate products obtained on the table depends obviously upon the nature of the slime; it is therefore necessary that the positions of the partition boards which are set in the circular receiving launder, dividing it into several segments, can be easily altered. The speed of the tables varies very much in different mills; in washing a very dilute slime at Clausthal large tables are run at a speed of one rotation in 3–4½ minutes. Commonly, however, they turn at a quicker rate, and especially when treating more concentrated slimes which are delivered upon the tables faster than dilute slimes. For example, to wash a meal-slime carrying 8–9 per cent. of solid matter a speed of 2–2½ rotations per minute is not unusual. High speed increases the capacity of the table; the limit in this direction is reached when tailings from the washer cannot be kept to a low grade. One to one-and-a-half horse-power is required for a table which is worked with the old-fashioned reciprocating scrubbing brushes, but when the cylindrical brush, above described, is employed, one-half to three-fourths of a horse-power suffices for the apparatus. A very fair washing capacity for a table is 15 cu. m. (22.5 tons, dry weight) of coarse meal, or 4 cu. m. (6 tons) of fine pulp in a day of twenty-two working hours. These figures apply to an easy-dressing ore (*e. g.*, to galena and copper pyrites in a quartz gangue), and vary widely with the character of the slime. A very fine or rich slime is delivered upon the table very slowly, so that the mineral may find ample time to settle, and comparatively little wash-water is used in treating it to avoid high losses in mineral—in a word, a rich or very fine slime requires slower washing than a poor or coarse one, and hence reduces the capacity of the apparatus. In constructing the table surface the grain of the wood is set at right angles to the direction of the slime flow; the wood swells and raises small ridges which act favorably in hindering the sliding motion of the fine mineral. From time to time the table surface is purposely roughened with a sharp pronged rake.

A round table with inward flow is not an uncommon form of slime washer. It is shaped like a flat funnel, and the general proportions and action of the apparatus are similar to those of the coned table. The slime is fed upon the rotating table by overflowing from a fixed circular supply launder which extends around one-third or more of the outer perimeter of the apparatus. A second launder joins the first and completes

the ring about the table; wash-water overflows from it on to the table and produces middlings, just as in the case of the outward-flow apparatus. The true merits of each of these forms of slime washers are recognized in a number of dressing works, where both are used in combination. On the inward-flow table the slime is spread in the very beginning upon a large area, so that the current is comparatively small and the mineral has a large precipitating surface: these conditions favor the deposition of headings. As the slime flows down the table, the area becomes contracted, and the force of the current increases, so that none but the coarsest of the middlings can be deposited: this condition is unfavorable to the productions of barren tailings. The outward-flow table, on the other hand, offers a small area for the precipitation of headings, and a very large one, with a current of diminishing strength, for the deposition of fine middlings: it is therefore especially suited for producing barren tailings, and not so good for precipitating the headings. When used in combination, a funnel-table is mounted above a cone-table on a common vertical shaft, and the tailings from the first are immediately re-washed on the second. The result of such treatment is decidedly better than two successive washings on tables of the same form. In the disposition just described the inward-flow table has to treat more slime than the lower cone-table, and for this it is peculiarly well suited. The comparatively strong and rapid current that so effectually carries off the tailings promotes a large capacity, which is one of the characteristics of the inward-flow table. Of several such tables, 16 feet in diameter, washing the finest kind of pulp at Clausthal, each one treats 6¼ tons (of 2,000 pounds, dry weight) per day of twenty-two working hours. Under the same conditions the capacity of an outward-flow table was found to be a little over two-thirds as great. The products from a typical treatment of fine galena and blende slime coming from a hydraulic separator and washed upon a set of funnel and cone tables are as follows (subject, of course, to many modifications):

Upon the inward-flow table:

1. *Headings*, galena with 35–50 per cent. lead, according to the degree of purification to which washing is carried; dried and sold.

2. *Middlings*, galena, coarse blende and gangue; returned to the same table, or, preferably, washed once or twice on a sep-

arate table—or sometimes on a meal jig and then on a table—for galena and blende.

3. *Tailings*, blende with gangue and fine galena; delivered directly on to the lower table.

Upon the outward-flow table:

4. *Lower Headings*, a marketable second quality galena concentrate; or, more often, an enriched product which is re-washed—sometimes on the upper table—yielding a rich galena (sold), and a middle product, mainly of blende, that is once more treated for high grade marketable zinc sulphide.

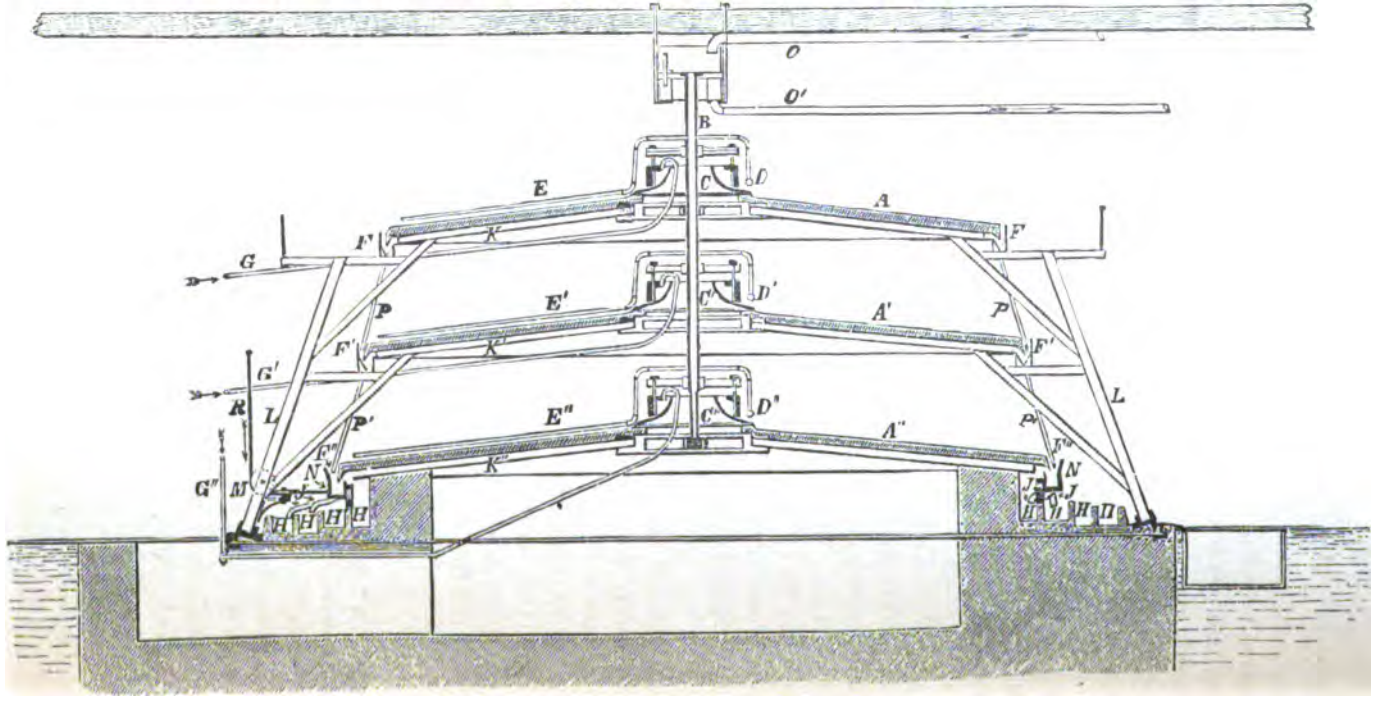
5. *Lower Middlings*, blende and gangue; usually washed with the middlings of the upper table, though occasionally returned to the hydraulic meal classifier.

6. *Lower Tailings*, barren gangue; discarded.

At one of the mills a pair of tables—the upper one 3.15 m. (10′ 6″) in diameter and the lower one with a diameter of 5.4 m. (17′ 8″)—treat in a day of twenty-two hours 72 cu. m. (96 cu. yds.) of slime which carries 6⅓ tons of fine pulp, or approximately 8 per cent. of solid matter. The headings of the funnel-table carry 45 per cent. of lead, and those from the lower, cone table 30 per cent. lead, and the discarded tailings run 0.40 per cent. of lead.

A stationary, continuous working, outward-flow table, designed by Linkenbach, the superintendent of one of the Ems mills, has been in use for several years. The table itself is fixed, but both the supply and receiving launders revolve. The washing is, therefore, of the same kind as upon a rotating table, but the advantages gained by the new design are cheaper construction and the possibility of using very large tables requiring but small motive force. To economize space in using such large washing surfaces, and to further cheapen their cost, several tables have been superimposed, producing the apparatus shown in section on Plate I.[1] The diameters of the tables A, A′ and A″ are respectively 6, 6½ and 7 m. (approximately 19½, 21 and 22¾ feet). Of three grades of classified slime that are washed at the same time on the apparatus, the coarsest sort is treated upon the upper table, and the medium and finest classes respectively upon the middle and lower tables. In the vertical axis of the apparatus is a revolving cast-iron pipe B; connected and revolving with it are

[1] Illustrated description of the new Linkenbach table: Wochenshrift des Vereins Deutscher Ingenieure, 1882, No. 9.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the vertical adjustable gates C, C′ and C″, the perforated wash-water pipes D, D′ and D″, and the inclined perforated pipes E, E′ and E″ which furnish water-jets for carrying the headings off the tables. The receiving launders F and F′ are stationary, but the lowest one, F″, is supported on small wheels and revolves. The bottom of each of the upper launders, F and F′, consists of a ring of flat funnels, the necks of which are 600 mm. (24 inches) apart; they deliver into a number of nearly vertical pipes P and P′. The slimes are delivered upon three distributing aprons by the supply pipes G, G′ and G″; then, in one revolution of the axle, they are discharged through the revolving gates and successively cover the whole washing surface. The clear water is supplied through the pipe O, and passes into the hollow axle and thence to the revolving wash-water pipes; an overflow is provided for in the pipe O′. Every part of the launders F and F′ receives in succession during one revolution the tailings, middlings and heads of the upper tables, and discharges these directly through the pipes P and P′ into the revolving launder F″. The latter is divided by partition boards into segmental sections of adjustable lengths; it revolves with the same angular velocity as the other movable parts of the apparatus, and therefore each section can be made to collect a separate product which it receives through the pipes P′ from above, or directly from the washing surface A″. Each part or section of the revolving launder is supplied with a spout, J, through which its contents are discharged into one of the four circular troughs, H, that connect with an extensive system of settling tanks.

The tables A, A′ and A″ are made of cement, 80 mm. (3¼ inches) thick, set upon iron sheets which are secured to iron frames K, K′ and K″, each of which has eight radial arms. The lowest frame, K″, is bedded on the foundation masonry, while the upper frames are sustained by eight iron supports L. The revolving motion is obtained from the belt R, which passes under the pulley M, and then around a ring of angle iron N, which forms the outer periphery of the revolving launder F″; from this launder the motion is transmitted to the central axle by means of the pipes E″ and D″ of the lowest table.

Single tables of the Linkenbach system have been built as large as 8 m. (26 ft.) in diameter. The apparatus at Ems concentrates the headings to 38 per cent. lead, but has been worked

up to 50 per cent. lead, and even, for the sake of demonstration, to 65 per cent. lead. A high concentration brings a greater proportion of mineral into the middlings and tailings, but with the first named lower concentration it is claimed that the tailings are unusually clean. The capacity of a single 8-meter table is 14½ tons (of 2,000 pounds, dry weight) of fine meal and pulp in 22 hours. For washing coarser slime the capacity is correspondingly greater.

End-Percussion Tables.—A large number of mills on the Continent still use the old intermittent end-bump table for washing sorted classes of meal and pulp. An apparatus of this type consists of a plane table, 4′ wide and 8′–12′ long, hung by four rods to as many iron standards, which form part of a fixed frame. The table is shoved forward by the action of a rotating cam-shaft, and tends to return by gravity to its first position; it is checked in this return movement by striking against a cushion, and the shock is transmitted to the slime which flows on a thin sheet over the table and to the deposit which accumulates upon it. The inclination of the table surface (2°–5°) and the amount of movement are subject to regulation, both diminishing with the size of the ore. A stroke of 5″–6″ is used for coarse meals and 2″ for pulp when an elastic cushion (usually in the form of a wooden beam, 3″–4″ thick) is employed. A cushion of this kind is generally preferred to a rigid resistance block. The cam-shaft imparts 16–24 displacements per minute to the table, and the cushion causes three rebounds between the regular strokes, so that the ore receives 64–96 shocks per minute in a direction opposed to the flow of the slime. In cases where a rigid block is used, the stroke varies from 2″–0.5″, and speeds of 150 strokes per minute are sometimes employed. When the apparatus is properly worked, each shock tends to smooth the surface of the accumulating mineral and to compact the deposit, but its principal effect is to arrest for a moment the flow of slime, imparting to it even a slight retrograde motion. This sudden check of the current brings to rest all the ore particles, many of which had assumed a sliding motion, and with the beginning of the renewed flow they commence to move forward by rolling, which motion (as stated on page 13) is the one best suited for slime sizing. In so far, therefore, the intermittent flow is an advantage, which, however, is partly counteracted by the direct unfavorable effect of the end-bump upon the

separation of the ore particles themselves: in an equal falling ore-class the grains of gangue, which are much larger than those of the mineral, have the greater inertia and are impelled farther than those in the backward movement given by the shock, so that they are continually obliged to overhaul the mineral particles during the periods of flow.

The tables are always so worked that in the first separation, barren tailings are produced. The deposit upon the table, after accumulating to a depth of 6″–8″, is divided into heads, middlings, and tailings, and each product (with the exception of the first tailings) is re-treated a number of times, according to its richness and the degree of concentration desired. The first middlings are sometimes subjected to finer comminution before being re-treated. The slimes which flow off the tables when concentrates are being re-washed, settle in runs and are worked over. The number of re-treatments varies from three to a dozen. At Freiberg, Saxony, the practice in one of the old dressing-mills is to produce seven slime classes by the hydraulic classification of stamped quartzose ore; the coarsest class, treated on a four-sieve jig, yields pure galena, marketable mispickel (arsenopyrite, specific gravity 6.3), impure pyrites mixed with blende, and building sand. The six finer classes are separately washed on end-bump tables, and each is subjected to eight operations, in the course of which the following final products are obtained in the order here named: Barren tailings (discarded), blende mixed with some pyrites, pyrites, mispickel, medium galena, and rich galena (all dried and sold).

The tables are conveniently arranged side by side in sets of three, with a space of 10–15 feet between the different sets, so as to allow room for the accommodation of intermediate products. Each set of tables works up a certain amount of stuff from the condition of raw slime to final product. The time required to form a deposit 8″ thick upon a table is about two hours for fine ore sands, and nine hours for pulp; in re-washing concentrates (which are always comparatively fine) six to nine hours are consumed in filling one table. During the removal of the deposited material the tables are frequently allowed to continue in operation. One table can treat at most 30 tons of coarse meal, or 5–6 tons of pulp per day of 22 working hours, but, as the headings from this washing are in nearly all cases twice re-treated, and at a much slower rate than the original

material, the average daily net capacity of all the tables of a mill cannot be counted at more than 8–10 tons of ore-slime for each table in treating coarse meal, and 1½–2 tons in washing pulp. There is obviously much hand labor connected with this system of washing, and a certain loss of float mineral is also incurred. No wash-water, however, is used in the process, and the slimes prepared for re-treatment are generally very concentrated.

The importance of a uniform quality of slime, and the impossibility of obtaining such by diluting precipitates with water (even with the use of various mixing tubs and mechanical stirrers), is shown by an examination of sections cut through the deposit upon an end-bump table. The deposit exhibits a decidedly banded structure: comparatively coarse grains are superimposed in layers upon finer ones, which frequently have a different shade of color, and thin, sharply defined seams of rich mineral are often found extending far down toward the tail end of the table instead of being deposited as headings with the rest of the material of its kind.

Side-Percussion Tables.—Rittinger's well-known continuous side-percussion table is much used for treating sorted meal-slimes in Austria, and also in Belgium, where its construction has been highly perfected. In Germany it is by no means uncommon, though introduced there to less extent than in the above named countries.[1] It is essentially an inclined-plane table which, being suspended from four fixed standards, is subjected to lateral displacement by a revolving cam-shaft, and then, by means of a spring, is driven back to its original position and strikes against a resistance block; it receives thereby a side shock which affects the thin sheet of slime that flows over the table surface. The washing surface is always divided by a longitudinal partition board into two equal parts (each 2 m. long by 0.9–1.50 m. wide), so that every table is virtually double. The inclination of the table (3°–6°), and the amount of displacement (⅜–2 inches), are subject to adjustment, the smaller figures applying in each case to the mode of setting for working pulp. Slime is charged at the head of the apparatus—in the upper right, or left-hand, corner—in a thin sheet

[1] In Sweden the Rittinger table has been introduced, notably in large dressing works erected near Falun for the treatment of a poor ore of finely disseminated copper pyrites, carrying a little gold. Heberle, *Das Neue Aufbereitungswerk zu Falun*, 1873.

8–12 inches wide. It flows down the table, and in its course the ore particles are driven toward one side by the lateral shocks, and describe as resultant a curved, diagonal path. Each individual shock has more effect upon the absolutely heavier particles of gangue than on those of the mineral, but the latter moving more slowly down the table are subjected to a greater number of impulses, and therefore diverge more than the grains of gangue. The different products of the slime thus follow different lines on the table and flow into separate receivers at the lower end of the apparatus. Wash-water is delivered in a wide sheet upon the head of the table, alongside of the slime; its quantity increases toward the heading, or percussion, side of the table. It promotes the downward course of material that is driven into its line of flow, acting with more effect on the gangue and intermediate products than on the fine head mineral, and it serves to prevent the deposition of any material upon the table. Because the wash-water flows in a thin sheet (and never in jets, as a portion of it does on round tables), a considerable quantity is consumed in carrying the headings off the table, and this unavoidably involves the production of a large class of middlings, containing more or less head mineral.

The washing action of the side-percussion table is identical with that of a stationary plane table. The shock has not, as in the case of the end-bump table, a beneficial effect upon the slime flow, but is merely a device for effecting a continuous delivery of each product. It does, however, influence the quality of the products—not as sized by the washing but as discharged from the table—for variations in the speed, or, more especially, in the throw, can bring together into the same line of flow particles that had been previously separated by washing. For any given slime there is a certain proper throw of the table which is found by experiment; the effect of increasing it is to bring middlings into the head mineral; by diminishing it a very pure heading is produced but a larger proportion of head mineral is carried off with the middlings. This control of the quality of the headings by means of the percussion is often utilized; that is, a certain proportion of the headings produced by washing is frequently allowed to flow off the table with the middlings; this portion will naturally contain the poorer constituents of the headings, and therefore the final head product of the table is raised to a cor-

respondingly higher grade. Accordingly the tables are usually run to produce highly concentrated headings, which constitute a very small class of the products, and one or two large classes of middlings and barren tailing. In the treatment of an ore carrying several minerals and rock gangue, four products are not unusual, and even five are formed in washing the Schemnitz ore-slime which has already been described. In that case the table yields:

1. *Extra Heads*, a very small quantity of gold amalgam with galena; the two products separated by hand-washing.

2. *Heads*, rich galena concentrate; settled in long runs which yield headings (sold), middlings (coarser than the headings—washed on end-bump tables), tailings (ditto), overflow (discarded).

3. *First Middlings*, copper pyrites, settled in runs—products treated as in (2).

4. *Second Middlings*, poor slime; passed through a small spitzkasten yielding an overflow (discarded) and a precipitate (re-treated on same table).

5. *Tailings*, barren slime; discarded.

It sometimes happens that the tailings from the percussion table carry fine, scaly head mineral, when the adjoining middlings are wholly free from it. This was the case in dressing works at Bleiberg, in eastern Belgium, near Aix-la-Chapelle. To prevent loss from this source a thin cleat is set diagonally across the flow of the tailings, from the washing toward the slime-feeding side of the table; the water above the cleat is stayed so that the mineral has time to settle; as soon as it touches the table surface it is affected by the lateral shock, and gradually driven over to the heading side of the table. Experience has shown that good results are only obtainable with an exceedingly uniform quality of slime, or else by constant attention and frequent changes in regulating the machine.

Many improvements have been made in the side-percussion table with a view to securing better separations, greater durability and a larger capacity. Very smooth washing-surfaces of fine grained wood, of wood covered with rubber cloth, linen and zinc, of glass, cement, slate, marble and planed cast and wrought iron have been tried at different mills. Surfaces of iron and of marble or slate are now generally adopted as the best—*i. e.* they are adapted for good work and are at the same

time very durable. At some works comparative experiments have led the preference of iron over marble for the washing surface,[1] but to any one closely observing the separation on an iron surface that has been in operation for a long time, the impairing influence of roughness that is due to rusting must be apparent. Iron, after having been much used in Belgian works, has yielded there in a number of cases to slate and marble. Great durability has been obtained by the use of firm masonry foundations, and by constructing the framework of iron, or, more recently, of Bessemer steel, with which material it can be made both lighter and cheaper. To avoid a tendency of the frames to creep sideways on their bedding, it is very good practice to neutralize the effect of the lateral shock by securing the framework of at least two double tables to a single foundation sill, and then, in working, to push the tables in opposite directions by cams set upon a common shaft.[2] The wear of the cams has been diminished by introducing rotating tappets, on the principle of the California stamp. The movable tongues which are commonly used at the lower end of the table to lead the separated products into different sections of a fixed receiving launder, have been done away with at several mills. Each tongue, in the ordinary arrangement, is secured by a thumb-screw to the table, and can be set to correspond with the line of division of two distinct classes of material. When worn, however, the tongues are apt to shift their positions with the continual shocks, and they always shorten the active separating surface of the table. Movable receiving trays of zinc or sheet-iron have been substituted. These receivers are 12–18 inches long; they set within the fixed foot launder, along which they can be slid at pleasure, and are supported by small flanges upon the launder sides. The bottom of each tray inclines slightly and in a direction at right angles to the flow of slime; for every product there is a separate tray, each one being set with its upper end on the line of division between two products. The separated slimes flow upon the tray-receivers and are led through these into the various launder sections. Two or more receivers are often partially superim-

[1] See results of tests at Przibram; Transactions of the Am. Inst. of Mining Eng's. 1879, Vol. IX. p. 443.

[2] This mode of setting has been introduced at Dam, near Antwerp, in works treating a finely mineralized Sardinian ore of galena, blende, and copper and iron pyrites.

posed; they answer the same purpose as movable section partitions in the launder; should these be employed, however, each change in the position of a partition piece would necessitate a cleaning out of all precipitate that might have accumulated in the launder near that point, but this trouble is avoided by using the sliding trays.

The capacity of the table and the consumption of wash-water depend, as in other washing tables, upon the nature of the slimes—fine and rich material always requiring slower feed than stuff that is coarse or poor. The average capacity as given by Rittinger for one of the early tables with two compartments was 2½–3 tons of sorted stamp-meal in 24 hours—not including the final concentration of the middlings. The speed was 90–100 shocks per minute for ordinary meal-slime, and 120–140 shocks for finer stuff. The small capacity was due partly to the fact that only two-thirds of the washing surface are covered with slime, the remainder carrying nothing but wash-water, and partly to the character of the slime flow: this being of practically constant velocity—neither interrupted as on the end-bump table, nor diminishing in force as on the outward-flow round table—the supply must be small and very carefully regulated to prevent the mineral particles from *sliding* off the table with the current. But the principal trouble was recognized not so much in slow washing as in the time required to move the different products by percussion into separate lines of flow. Hence, as might be expected, a greater capacity was attainable with higher speeds—200–300 shocks per minute, and a throw of $\frac{5}{16} - \frac{1}{2}$ inch. Working under such conditions, a table with two compartments can treat 6 cu. m. (9 tons) of ordinary meal or 15 cu. m. (22½ tons) of coarse meal per day of twenty two hours, with a requirement of 1–1½ horse-power. The concentrate is, with rare exceptions, a high grade final product. In separating galena, blende and rock gangue, an almost pure galena heading can be obtained, running only 1–2 per cent. of blende, and at the same time the tailings can be of so low a grade as to be discarded, but the quantity of headings produced by such a separation is very small—much of the lead remaining with the zinc middlings, which require re-treatment.

Various Patented Slime-Washers.—In addition to slime jigs, round tables and percussion tables, a number of other machines have been designed for slime washing, but these devices, most of which are patented, have found but very limited introduc-

tion in practice. An apparatus consisting of an endless canvas or blanket belt moving across the line of the slime-flow is quite an old form of continuous plane table, which is sometimes used instead of the old stationary blanket tables for washing gold or amalgam, or argentiferous galena slimes. The nap of the cloth prevents, to a certain extent, the loss of fine mineral particles, which are apt to float off with the current. The belt is inclined in the direction of its breadth, and travels over two revolving drums. The ore-slime is delivered upon the belt at one end of the washing surface, and the poorest stuff flows down at once into a tail launder. The depositing material is moved sideways by the progressive advance of the belt, and is subjected to the action of a broad current of clear water, which carries off a certain portion of the material into a launder for middlings; the headings remain on the belt until it passes below one of the end drums, and then they are removed by fine sharp sprays of water. A variety of machines of this type have been designed, differing only in points of detail that are intended to diminish their cost or increase their durability. For the treatment of large quantities of slime such machines are not used; one of the difficulties not yet overcome is to make cheap and durable belts for them.

The Frue vanner, so well known as a slime-washer in American practice, has only been tried in an experimental way, and has as yet attracted very little attention. This machine belongs to the class of continuous plane washers; it consists essentially of an endless rubber-coated canvas belt, which is set on rollers at a slight inclination, so that the washing surface can move upward against a flow of slime and wash-water. A lateral oscillating or vanning motion is given to the belt to promote a settling of the mineral, and to distribute the sheet of slime evenly over the washing surface. The deposit on the belt is carried over a revolving drum at the head of the machine and forms the "concentrate"; the slimes flowing over the lower drum are the tailings; the washer produces no middlings.[1] Very fine head mineral will naturally settle at a lower

[1] That the vanner forms no middlings would in foreign mills frequently prove a serious objection to it. In Western practice, however, the finely divided gold or silver bearing mineral is usually the only concentrate sought, and middlings of other minerals have but small value. The finely stamped slimes of meal and pulp are there led, without hydraulic classification, from the batteries directly to the slime-washers. By passing the material successively over two vanners, it is possible, under very favorable circumstances, to extract 90 % of the precious metals contained in the ore. The

point on the belt than coarser mineral of the same kind, compared with which it will require more time in reaching the head drum of the machine, and will be subjected for a longer period to the flow of slime and wash-water, with all the greater chance of being carried over the lower drum by the current. On this account the vanner does not seem as favorable for the production of low grade tailings as the outward-flow round table on which the force of all the currents diminishes as these spread over an increasing area toward the lower part of the apparatus. The characteristic vanning motion of the machine, however, compensates more or less for its defect. It facilitates the flow of the slime, and more especially of the larger, easily rolling particles of gangue, while the fine mineral, when once deposited on the belt, adheres closely to it and is but slightly affected by the lateral shaking motion.[1] The favorable effect of vanning upon the flow of slime permits the use of very concentrated slimes and comparatively little wash-water, and insures a large capacity. One machine commonly treats 6 tons of fine stamp-meal per day (not including the re-washing of tailings if such be necessary), though a capacity of 12 tons has been attained with highly favoring conditions. Two machines generally receive the slimes from a battery of five stamps.

Tossing Keeves.—The English dolly-tub, or tossing keeve, which in its earliest form was a simple hand tub, is still used in many English works in treating imperfectly sorted slimes. In its present form the apparatus usually consists of a fixed tub within which a stirrer rotates about a vertical axis. Outside of the tub is a small mechanical hammer which, when in operation, taps the tub fifty to eighty times a minute. The tub is one-third filled with water, to which the fine ore or concentrate is gradually added until the consistency of a thick slime is obtained. The stirrer is kept revolving during the mixing period —about 15 minutes—and imparts to the slime a rotary motion.

saving of 80–85 % is a more usual result in practice. It must be borne in mind that as a rule the ore-slimes in the West are of a very much higher grade than those in Europe, and it is found from a number of authenticated cases that the western tailings which carry only 10–15 % of the head mineral contained in the slime are as rich and even richer than many of the unwashed slimes that are treated in foreign mills. The home practice could most probably be improved in many cases by introducing a preparatory hydraulic classification.

[1] This mode of action will suggest at once why the vanner has found particular favor in the treatment of fine stamp meal and pulp—the mineral being nearly always reduced by stamping to a finer condition than the gangue.

Then the stirrer is raised out of the keeve by a pulley cord, being at the same time disengaged from the transmission gearing, and the hammer is set in operation to promote the settling, which requires 15–20 minutes. The gradually diminishing rotary motion of the water has the same effect on the slime particles as a deep current of decreasing velocity, and the material settles in layers of equal-falling grains. After the deposit has settled, the top water is tapped off, and the material is shovelled out of the keeve, forming several well defined products—a rich "bottom," a class of middlings or "krazer" and a fine, barren "top." Sand slime, unless of the finest kind (1.4–1 mm. or $\frac{1}{16}-\frac{1}{25}$ inch) is too coarse to be advantageously treated by "tossing," but meals are well suited for it; pulp slime, on the other hand, is too fine, requiring too much time for depositing. The headings from Cornish buddles are always purified by tossing, if a sample lot is found upon vanning to contain very fine dirt mixed with rich mineral of medium fineness. The washing of enriched tin concentrates at the Dolcoath mill, at Cambrae, Cornwall, may serve as an illustration of the practice. These concentrates are the headings from a set of round buddles; they carry 60–65 per cent. of *tinstone*, mixed with a certain amount of rock gangue and some very fine red oxide of iron, produced by the roasting of the pyritiferous tin ore in meal size. The material is subjected to "rag-tossing," and yields bottom, krazer and top products, each of which is re-buddled—the bottom product but once, the others several times. By buddling the "bottom" a separation into heads, middlings and tailings is obtained; the two poorer (and coarser) products are re-treated, but the headings are subjected to "clean-tossing" which is repeated four or five times, producing finally a marketable concentrate carrying over 90 per cent. of stannic oxide, and a poorer "top" which is re-tossed or re-buddled according to its fineness. The purpose of the treatment is to separate by repeated buddling the coarse gangue particles from the finer mineral, and by repeated tossing to purify the concentrate from the impalpable ferric oxide which holds to the much heavier *tin* with surprising fixity. The purification by tossing is particularly applicable to meal concentrates, which, owing to imperfect slime sorting, contain a considerable percentage of very fine, usually slaty dirt, that adheres closely to any washing surface, and cannot be separated from the mineral on tables without incurring considerable loss. The tapping of the

hammer on the side of the keeve is very advantageous; by shortening the time required for settling, it extends the application of tossing to much finer sizes of material than could otherwise be profitably treated.

Comparisons Between Different Slime Washers.—In discussing the relative merits of the four prevalent types of slime washers—the fine jig, the round table, and the end and side percussion tables—the results obtained with these apparatus in various mills have to be most carefully examined lest they prove misleading. Even experiments systematically conducted in a single mill can easily lead to error if they be made the basis for broader generalizations than a rigid adherence to the conditions of the experiments permit. In dressing a given kind of slime, the capacity of the slime washer, the degree of enrichment of the concentrate and the quality of the tailings are interdependent quantities, all three of which must be known in forming an opinion as to the efficiency of the apparatus. Moreover, the external influences which affect the treatment are in no two mills identical; and when additionally taking into account the great diversity in the character of ores, the necessity for a very circumspect consideration of the results of any particular treatment must be evident. Dressing establishments which are situated near smelting works generally run for clean tailings rather than for high grade concentrates, and this is especially the case when the smelters treat several kinds of concentrates whose gangue particles mutually flux one another. It is not unusual to find in the dressing of an ordinary galena-blende ore that the slime middlings of blende have to be concentrated by repeated washing to a higher percentage of metal than the galena headings, mainly because transportation to the zinc smelters is over a greater distance and more costly.

Meal jigs have been used at Clausthal for treating two classes of sorted slime between the sizes of 1 and 0.5 mm. For the purpose of experiment, slime of the same class was treated on inward-flow tables, 5.5 m. in diameter. The advantages in favor of the table proved to be smaller cost of the apparatus, fewer repairs, less motive power, less attention required from workmen, greater capacity and a better separation. More galena was obtained in the headings and less in the blende middlings; the tailings were immediately re-treated on a lower table. The better separation is partly due to the fact that the ore-gangue consists of quartz and spathic iron; much of the

latter settled upon the mineral bed of the jig, forming after a time a compact layer which impeded the sorting and necessitated periodic stoppages for its removal. After obtaining such results some of the jigs in the slime departments were replaced by inward-flow tables, and all will eventually be superseded by them. On the other hand it is reported[1] that at Scharley, in Upper Silesia, in washing a blende ore carrying some galena, 34 round buddles have been supplanted by six continuous sand and meal jigs, and that thereby the amount of lead in the zinc concentrate has been reduced from 1.5 per cent. to 0.1–0.2 per cent. The gangue in this ore is dolomitic, and the slime is therefore "tough"; sand and coarse meal slimes of this ore-class are thoroughly agitated by jigging, and hence more easily cleansed from the fine adherent gangue than by the quieter action on buddles or tables. Such and similar special cases, found only by actual experience, will warrant the use of jigs for the sizing of hydraulically sorted meal slimes, but as a general rule the jigging of material finer than 1 mm. has not been satisfactory. The Clausthal works were regarded as leading advocates of very fine jigging, and their change to the double inward and outward-flow tables will probably check further movement in that direction.

Side-percussion, or Rittinger, tables have been used with signal success at some mills, while they have been discarded as worthless at others, notably at some of the large government mills at Przibram. The constant attention required at the machine, unless the slimes are of a very uniform character, is a point always urged against it. The principal reason why the apparatus has frequently met with poor success lies probably in its application to the treatment of slimes for which it is unsuited. All the mineral upon the table must be rolled to one side of the machine by lateral shocks, and to move in this manner with facility the particles must not be too small. Very fine pulp, as is well known, is peculiarly adherent to any washing surface, and therefore not suited for treatment by this method.[2] Coarse material, on the other hand, is apt to roll too easily under the effect of the shocks, and so increases the difficulty of producing

[1] Judges' Reports to Centennial Commission, 1877. Vol. I. p. 293.

[2] The adherence may be partly due to a feebler current very close to the table surface, but its main cause lies in the small distance between the centre of gravity of each particle and its supporting base, and consequently in the short leverage of any overturning force.

a good separation. Experiments with the Clausthal ore (previously described) on a table having a fine grained wooden surface, showed that slime containing mineral coarser than 0.5 mm. and finer than 0.25 mm. ($\frac{1}{50} - \frac{1}{100}$ inch) could not be satisfactorily treated. Washing surfaces which are made of other material alter these figures to a certain extent; but the practice of treating pulp slime on percussion tables, even though these may be fitted with very smooth marble surfaces, cannot be generally recommended. Rittinger tables are best adapted for washing sorted coarse meal slimes (which carry *mineral* within the above-named limiting sizes), and their use is profitably extended to finer material only when very high grade headings are required. They have been very successfully used in extracting fine galena from blende middlings of meal, and fine sand, jigs. The side-percussion table has sometimes been styled the connecting link between the jig and the round table. It does occupy an intermediate position in some cases, though the combination of inward and outward-flow round tables has been found suited to meals as coarse as any treated on the percussion table. The special adaptability of the latter to collect headings which are contained in very small quantity in the slime, and the high degree of concentration which it can effect (often at the cost of producing a large class of middlings), are elements fully as important as size in determining which type of apparatus to employ.[1]

The end-percussion table still maintains a prominent position, notwithstanding the manifest disadvantages of working without a continuous discharge of each of its products. It is a very simple machine to manage, and both the headings and middlings can by successive operations be very easily enriched to just the grade required. For this reason the table is often used in working up blende products. The blende, to obtain a favorable market price, must not carry over a certain percentage of galena, and this condition is readily attained by successive operations on the table. Experiments on Przibram quartz-

[1] Compared with the Frue vanner, the side-percussion table seems better adapted for treating coarse meal slime, and less so for pulp slime. Both machines produce high grade concentrates. The percussion table offers the advantage of producing middlings, and is cheaper, but the vanner consumes less water and less power. In treating fine meal slimes the concentrations of the two machines and their working capacity and saving of head mineral should be about the same, so that preference for washing this class of material will be given to one or the other machine according to the relative importance of the above-named characteristics.

ose ore (previously described) showed that the table was not suited for coarsely stamped sands—1–1½ mm. in diameter. For such stuff a sand jig (with 6–8 mm. stroke, and stayed water) effected a much larger saving of head mineral. Similar results have been obtained elsewhere: in the blende department of the Ems mills end-bump tables have been replaced by four-sieve jigs for washing two sorted sand classes between the sizes of 1½ and 1 mm. Further experiments[1] to compare the results obtained in washing very fine pulp on a sweeping table, a Rittinger table (2.5 m. long) and an end-percussion table (4 m. long and worked with strong shock) proved the superiority of the last-named machine in point of capacity, mineral saving, value of products, consumption of water and cost. The results would have been far more interesting if a round table had been drawn into the experiments, but such as they are they will serve as confirmatory evidence that the Rittinger table is not adapted to dressing fine pulp.[2] The experience of several mills is that tough (slaty or calcareous) slimes cannot be successfully treated on the end-percussion table. For washing quartzose meal, however, and pulp slimes, especially in blende dressing, this machine is likely to remain in use for some time in the mills where it is now employed. Its gradual abandonment, however, in favor of continuous machines may be inferred from the fact that it has not been adopted in any of the large first-class establishments which have been erected in recent years. The prospect of its introduction where the value of labor is high can never be entertained.

Round tables, which are the machines most commonly used for washing meal and pulp slimes, possess a wide range of utility. The inward-flow table has treated coarse meal satisfactorily, while the outward-flow, or cone table, is, under many circumstances, the most suitable continuous apparatus hitherto designed for washing fine pulp. A round table generally produces, in the first operation, marketable concentrates (though not of as high a grade as the similar product from a side-percussion table); its middlings, if not too fine, can be treated to advantage on a Rittinger machine, while the tailings are delivered at once to a lower round table. Decided advantages

[1] Oestr. Zeitschrift f. Berg-und Huettenwesen, Vol. XXVII. p. 101.

[2] The Schemnitz practice, as indicated under the subject of *Hydraulic Classification*, shows that the end-bump table is there regarded as filling an intermediate position between side-percussion, and round, tables.

for this machine are low cost and small items for repairs, labor and power. Fine pulp carrying less than 2½ per cent. of very low grade argentiferous galena has been washed on it with profit.[1] It seems beyond doubt that on the continent the round table will remain the leading type of slime-washer until some new apparatus of radically different and better design shall supplant it.

Crushing and Drying of Concentrates.—Many foreign smeltworks require that galena concentrates be reduced to a 3 mm. (⅛ inch) size before subjecting them to metallurgical treatment. Accordingly dressed concentrates from jigging are sometimes drained on screens,[2] or they are dried by simple exposure and then passed together with "mineral" from hand sorting to a set of reducing rolls, or to a Chilian mill. Concentrates from the slime department naturally require no further reduction, but they must be dried in the dressing-mill to reduce the cost and diminish losses of transportation. A very simple contrivance for separating most of the water from these fine products is a tub which is tapped on the outside by a self-acting hammer, or a box balanced upon a horizontal axis and rocked back and forth by an eccentric, so that it taps the floor at each stroke. The deposit settles down and compacts well in either kind of apparatus; a layer of water several inches deep forms on the surface and is drawn off. The dried mineral contains from 1½–4 per cent., and in some districts even 10 per cent., of water. It is shovelled out of the drying-box, is sampled, assayed and weighed, and is then packed for shipment.

(*To be continued.*)

STEEL ANALYSIS.

By WM. F. BRUGMAN, Ph. B.

IN presenting the subjoined methods of chemical analysis for publication, no claim for originality or priority of publication is advanced, as F. A. Emmerton, chief chemist of the Joliet Steel Co., with whom I have been associated, has not

[1] Such working results in treating pulp have not been reached, to the writer's knowledge, with any other slime washer.

[2] Endless belt screens with an up-and-down shaking motion have been introduced for draining coal after jigging, and are proposed for the same purpose in ore dressing.

only collected and adapted these methods, but has published them in brief form in the Trans. of the Inst. of Mining Eng. They are therefore particularly addressed to those interested in this branch of analysis, who have not had their attention attracted to these particular methods.

Combined Carbon.—The method used is a modification of that proposed by Eggertz. One grm. of the drillings is dissolved in 15 c.c. HNO_3, 1.20 sp. gr., in a large test tube immersed in cold water. The tube, covered with a glass bulb to prevent evaporation, is transferred to a water bath maintained at a temperature of 90° C.

At the expiration of 30 minutes, the tube is removed to a cold water bath, and when cool, the solution is filtered and compared with a set of colors made as follows: about equal portions of a strong solution of coffee and caramel are mixed, and further diluted with a mixture of equal parts alcohol and water until the color obtained is of exactly the same intensity as that obtained by operating upon a weighed quantity of standard steel, as described above. This, in the case in question, constituted the highest color of the series, corresponding to .44%C; and this, diluted with an equal volume of the alcohol mixture, gave the lowest color, .22% C. The intermediate colors were made by adding the requisite amount of alcohol mixture to the original .44% color. The solutions are contained in 5/8-inch test tubes mounted in a suitable framework. In summer the colors are renewed about every three weeks; in winter about every five weeks, or when tested occasionally with the standard steel an error of not more than .01% is perceived.

Silicon.—One grm. of the drillings is dissolved in 20 c.c. of a mixture of 4 HNO_3, 1.20 sp. gr., and 1 H_2SO_4 (conc.). The dish is kept well covered and the evaporation continued until fumes of H_2SO_4 appear; when this point is reached the dish is removed, cooled, and sufficient water added to contents, which with the aid of heat dissolve readily. The solution is filtered on a filter pump, and washed four times alternately with hot HCl and H_2O. The filter becomes sufficiently dry to incinerate at once. When analyzing steel, the presence of "scale," or Fe_3O_4, must be guarded against; this being insoluble would vitiate the result; also in operating upon pig iron, a magnet should be used to separate the drillings from the slag and sand which invariably contaminate pig-iron drillings. A determination can be made in 45 minutes.

Manganese.—A volumetric method perfected by Vollhard is employed. One grm. is dissolved, evaporated to fumes of H_2SO_4 and solution made in water as in the determination of silicon. This solution is transferred to a 300 c.c. flask, and Na_2CO_3 added until a light-red color is reached; the neutralization is completed by adding excess of ZnO in suspension, and diluting to the mark. The bulky precipitate of $Fe_2(OH)_6$ is separated by filtration, and 200 c.c. of the filtrate transferred to a flask; a drop of HNO_3 added and heated to boiling. A standard solution of $K_2Mn_2O_8$ of convenient strength is added from a burette, until a drop produces a pink coloration, the flask being shaken after each addition. This point is the end reaction. This method has only been employed for determining amounts below 2.0%, and has given very satisfactory comparisons with the phosphate method.

As commercial ZnO generally contains manganese, zinc dust, etc., it is necessary to purify it. To do this HCl is saturated with ZnO, bromine added, and the maganese allowed to separate in a warm place. This is filtered off, the filtrate heated to boiling and diluted with several times its volume of hot water; the ZnO separates on the addition of an excess of NH OH. The washing must be very complete, and the residual ZnO of the consistency of cream.

In spiegels and other products, manganese is estimated by the basic acetate method with final precipitation as phosphate. Great difficulty is often experienced in obtaining the latter precipitate crystalline, but this can be surmounted by letting precipitate and solution stand for some hours at a temperature below the boiling point.

Phosphorus.—Ten grms. are dissolved in 150 c. c. HNO, 1.20 sp. gr., in a 5-inch evaporating dish, and evaporated to dryness on a sand bath. The heating is continued at a somewhat reduced temperature for half an hour to render the SiO_2 insoluble. At this point the dish is removed, cooled, and sufficient HCl (conc.) added for solution, the excess of which is then evaporated off. This solution is diluted and filtered, the filtrate made ammoniacal, and the $Fe_2(OH)_6$ dissolved in the same beaker without previous filtration, in a slight excess of HNO_3. An excess of molybdate solution is added, and the liquid kept at a temperature of about 70° C. for four hours, when the precipitation will be complete. Repeated experiments have verified this. The solution is filtered and the precipitate washed moderately with

a 6% solution of NH_4NO_3, redissolved in excess of NH_4OH, and sufficient magnesia mixture added. This precipitate is very flocculent and subsides completely in two hours, when it is filtered, dissolved in HCl and the filter thoroughly washed. The solution is thus freed from the minute quantity of SiO_2 which escapes the preliminary evaporation to dryness. About .100 grm. citric acid and ⅓ its volume of NH_4OH (conc.) are added to this final solution, which does not exceed 40 c.c. Four hours have proven sufficient for the completeness of this precipitation. Duplicates by this method always agree within .005%, and comparisons made with chemists using reliable methods have been very satisfactory.

Sulphur.—Five grms. are treated with 80 c.c. warm HCl (1 : 1) in a flask connected with two large test tubes containing a solution of KOH (1 : 5), in such a manner that the gases evolved bubble through both. When the action subsides somewhat, heat is applied gently, until it is apparent that the metal is dissolved; an aspirator is then attached until about 500 c.c. of air have been drawn through. The KOH, which retains the H_2S as K_2S, is diluted in a beaker to about 300 c.c., acidulated with HCl, starch solution added and a standard solution of iodine run in without delay, until a drop produces a blue color. KOH often contains iron, probably as a ferrate; this must be avoided.

The iodine solution is prepared as follows: 5 grms. I are dissolved in water with the aid of 7 grms. KI, and diluted to a litre. The strength is found by titrating against a $Na_2S_2O_3$ solution of known strength. The hypo. solution is prepared by dissolving 25 grms. $Na_2S_2O_3$ in a litre of water, to which about 2 grms. $(NH_4)_2CO_3$ are added to prevent the solution from changing. A solution of 4.92 grms. pure dry $K_2Cr_2O_7$ in 1 litre H_2O is made, each c.c. of which will liberate .0127 I when used in the following manner: to 20 c.c. of the $K_2Cr_2O_7$, 1 grm. KI is added dissolved in H_2O, and about 15 c.c. HCl (1 : 1). This liberates $20 \times .0127\ I = .2540\ I$. From a burette the hypo. solution is added until a greenish color is shown, then starch solution, and the addition of the hypo. solution is continued until the blue color disappears. This gives the strength of hypo. solution. The iodine solution is standardized by taking a measured quantity, and adding the hypo. solution until the color is discharged. For example, suppose 20 c.c. $K_2Cr_2O_7$ solution = 21. 80 hypo. solution, and 20 c.c. I solution = 7.60 hypo.

solution; then as 20 c.c. $K_2C_2O_7$ solution = .2540 I, and 21.80 hypo. solution = .2540 I, then 1 c.c. = .01165 I. But as 7.60 c.c. hypo. solution = 20 c.c. I solution, then 20 c.c. I solution = .08854 I, and 1 c.c. = .004427 I. The reaction which takes place between the I solution and the disolved H_2S is thus: $H_2S + I_2 = 2\ HI + S$. According to this reaction, 254 parts I = .32 of S; hence 1 c.c. of the above I solution which contains .004427 I, is equal to $\frac{32}{254}$ of that amount of S, or 1 c.c. = .0005577 S. This method gives very concordant results with the gravimetric method, though less than 50 minutes are occupied in completing the analysis.

Iron.—This is determined by a standard solution of $K_2Cr_2O_7$, and is essentially the method described in text books, with this exception, that the reduction of the solution is attained by means of $SnCl_2$ as follows: to the concentrated HCl solution of the ore, $SnCl_2$ solution is added cautiously until the color disappears, and then about 100 c.c. Hg_2Cl_2 solution is added, and the whole diluted to about 600 c.c., and titrated as usual. An hour suffices for a determination.

Copper.—One grm. is dissolved in 10 c.c. H_2SO_4 (1 : 4) in a 100 c.c. beaker, diluted to 50 c.c., 5 c.c. concentrated solution of $Na_2S_2O_3$ added, and boiled for 15 minutes. The large precipitate of S, containing the CuS, is filtered, dried, and burned in a porcelain crucible and treated with 1 c.c. ($HNO_3 + 3HCl$). This is diluted with water, rendered ammoniacal and filtered through a small filter into a comparison tube. The comparison is made with a standard ammoniacal solution of $CuSO_4$.

Total Carbon.—Three grms. are treated with a neutral solution of CuSO in a cool place for six hours. The precipitated copper is filtered on an asbestos filter, washed, and transferred to a flask with the aid of a few c.c. H_2O if necessary. 8 grms. CrO_3 and 50 c.c. conc. H_2SO_4 are introduced into the flask and the determination conducted as usual.

FROGS AND SWITCHES.

By W. B. PARSONS, Jr., A.B., C.E.

In the matter of maintenance of way there is probably no part so little practically understood by engineers, and often so badly treated theoretically by trackmen, as frogs and switches

and their location. Yet really there should be no trouble above the exercise of proper care and attention. In locating the majority of switches there is no need of a transit or any instrumental work, certain writers to the contrary notwithstanding. The only cases where a transit is of service are: first, when the curve of the "lead" is to be continued for some distance beyond the frog; and secondly, where frogs of a very high number are used, whose leads are rather long to be accurately lined by eye.

A switch consists of a frog, lead rails, moving or switch rails, switch gate with its necessary connections, and a set of switch timbers.

Frogs are now known by numbers representing the ratio of length from frog point to heel, to breadth at heel. The old system of letters, which is entirely arbitrary and meaningless, is fortunately rapidly dying out. These letters are AA, A, B, C, and are determined by the following distances from the point to where the frog is six inches across:

AA, 5′ 2″; A, 4′ 0″; B, 3′ 4″; C, 2′ 9″.

For ordinary switches a No. 8 frog will be found the most serviceable, a lower number giving too sharp a curve. For switches at junctions, or where trains pass at high rates of speed, a No. 10 is the lowest number advisable, and even a No. 11 or No. 12 is to be preferred. The frog of the present day is some form of steel rail frog. The rails are either riveted to a wrought iron plate one-half inch thick, or else are keyed together in a variety of ways according to different makers' views. The choice is a matter of personal preference. There is another form of rail frog which is steadily growing in favor, and already is the standard on the Pennsylvania R. R., N. Y. Elevated Railways, and other roads. This is the spring frog. It undoubtedly possesses great advantages. Inasmuch as one of the wings is always lying close against the point, the wheel tread has a full and unbroken bearing. Thus the point is saved from battering, the frog's life necessarily prolonged, and the jar to the rolling stock incident to running over a worn-out frog done away with. Of course a spring frog needs more attention to keep it clear and free, especially in winter during periods of ice and snow, but a careful application of the pick and shovel and a little salt will prevent any trouble. As a side remark, let me add here, that immediately after a snow-storm the first thing to be cleared is the switches. Snow and

ice should be carefully removed from the head chairs, switch rods, and frog, and in fact the snow from the whole switch from frog to further end of moving rails should be entirely removed. Then a little salt sprinkled on the frog and head chairs, around the rods and under the moving rails will prevent the switch from being so frozen as to be useless. Frogs should be made sufficiently long to permit the ordinary angle plates being used at the end joints. There is always more jar at the frog, so special care must be taken to keep it tight in place; and the angle plate firmly bolted and well spiked gives a much more rigid connection between rail and frog than the simple fish plate. For a No. 8 frog an extreme length of ten feet will be found convenient. The old cast-iron frog is rapidly becoming on first-class roads a matter of history, and at the present day has but one suitable place—the scrap heap. Any frog which necessitates the cutting or scoring of the frog timbers is to be avoided.

The "lead" of a frog, sometimes called the frog distance, is the distance from the frog point to the head block or toe of the moving rail, measured on the main track rail. The lead depends on frog angle and throw of switch. The rails of the turnout running from the head block to the frog are sometimes called lead rails. It is this matter of lead that has proved the stumbling block to many an engineer, and given the trackman a splendid chance to display his contempt for "theory" with the natural result of detriment to the switch. Henck (pp. 32 and 33) deduces his formula, which is not only unwieldy but is also incorrect. He bases his investigation on the view that the switch or moving rails are as it were hinged, and so remain straight after being thrown. He then calculates the curve required to join them with the frog; taking the line of the moving rails, after being thrown, as one tangent and the side of the frog prolonged as the other; the point of intersection falling between the rails of the main track. He also talks of the switch angle and a switch rail of arbitrary length. Now in reality the length of the switch rail depends on the frog angle (or frog No.) and throw of the switch, and moreover the rail when thrown does not remain straight, but bends itself in a regular curve, hence there is no "switch angle." Trautwine too, in his "Hand-book for Engineers" (up to the last edition, when he makes correction), was deceived by the same fallacy, and thinks that lead is dependent on length of switch instead of

frog angle and throw. Starting with this hypothesis we can calculate the "lead" and length of switch rail required for a given frog angle as follows:

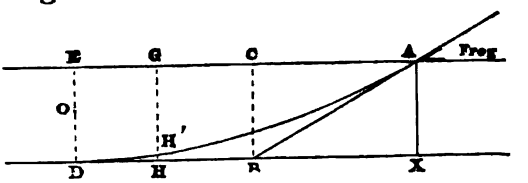


FIG. 1.

B is point of intersection of side of frog prolonged and main track, the intersection angle *A B X* evidently being equal to given frog angle. The problem is then to join these two tangents with a regular curve.

In triangle A B C having angle C B A = frog angle, C B = gauge, find A C and A B.

Now A B is tangent, or T of required curve and frog angle = I.

Then $R' = T \cot \frac{1}{2}I$, will give radius of outside rail, and R = R' — gauge = radius of curve. Distance A E = E C + C A = T + C A = distance from heel of switch rail to point of frog.

To find length of moving rail, *i. e.*, that portion which should be left unspiked so as to be free to move and carry out the curve, we have to calculate what length of curve is necessary to produce tangent deflection equal to "throw" of the switch rail. This is done by Henck's formula:

$$C = \frac{a \times 50}{\sin D}.$$

In which C = length of moving rails required and a = twice the throw (chord deflec. = 2 × tang. deflec.)

The throw is almost universally 5". This length of moving rail is evidently distance from origin of curve to head block, the latter being denoted in Figure 1 by H G, where H H' = throw. Therefore A G or lead = A E — E G.

Calculating "T," "R," "lead," etc., for frogs varying by ½ Nos. from 5 to 13, and adding similar deductions for the lettered frogs for sake of comparison we form the following table. The last column gives the distance from head block to point of crotch frog in case of 3-throw switch.

It is better to avoid, if possible, a 3-throw switch. Two frogs abreast of each other are hard to maintain, besides giving a double jar to the passing truck.

FROG TABLE.

No.	Frog Angle.	Tangent Length in Feet.	Radius in Feet.	Degree of Curvature.	Length of Moving Rail 5″ throw.	Lead. Head Block to Frog Point.	Total Length of Lead.	HB to Crotch Frog in 3-throw.
5	11° 29′	23.25	234.43	24° 38′	14.02	32.59	46.61	19.09
5½	10 26	25.91	283.83	20 17	15.43	36.00	51.43	20.89
6	9 33	28.26	338.60	16 59	16.85	39.38	56.23	22.97
6½	8 49	30.62	396.87	14 28	18.25	42.69	60.91	24.83
7	8 11	32.97	460.58	12 28	19.66	45.98	65.64	26.80
7½	7 39	35.33	528.75	10 51	21.07	49.43	70.50	28.72
8	7 10	37.68	601.70	9 32	22.48	52.69	75.17	30.64
8½	6 45	40.04	679.80	8 26	23.89	56.14	80.03	32.57
9	6 22	42.39	761.98	7 31	25.30	59.40	84.70	34.49
9½	6 02	44.75	849.06	6 45	26.72	62.66	89.38	36.39
10	5 44	47.10	941.19	6 05	28.11	66.13	94.24	38.35
10½	5 27	49.46	1038.00	5 31	29.51	69.47	98.98	40.29
11	5 13	51.81	1137.75	5 02	30.92	72.47	103.39	42.18
11½	4 59	54.17	1247.02	4 36	32.34	75.97	108.31	44.18
12	4 46	56.52	1355.75	4 14	33.74	79.30	113.04	46.05
12½	4 35	58.88	1470.92	3 54	35.14	82.38	117.52	47.97
13	4 24	61.23	1591.79	3 36	36.56	85.66	122.22	49.74
C	9 45	27.75	325.34	17 40	16.47	38.73	55.20	22.28
B	8 30	31.79	427.79	13 25	18.88	44.35	63.23	25.51
[1]A	7 10	37.68	601.70	9 32	22.48	52.69	75.17	30.64
AA	5 15	51.37	1120.40	5 07	30.59	71.92	102.51	41.45

Now for the moving rails and their connections. The switch gate needs no description and can be passed over with the note that the target should be large and conspicuous and always kept well painted. The moving rails are held together by switch rods; in number at least four, better five. Some roads have them made of flat iron with lugs riveted on to grasp the foot of the rail. But rivets will work loose. Better to have them forged solid out of square or round iron 1″ to 1½″ in diameter. One of these is close to end of rail and the others distributed back at intervals (if there are 5) of 4 ft. A rod of similar construction, except that one end has an eye, connects switch stand with one of the rails. It is called the "connecting-rod" and in order to have the switch gate at proper distance from track should be 6 ft. long. The moving rails and stub rails come together and are held in place in head chairs, which are best made of malleable iron. The space between the moving and stub rails should be about 1½″, so that when the rails expand they will not bind tight in head chairs. Too great a space produces battering.

The switch, from the frog to the moving rails, rests on special kind of ties or switch timbers. They should invari-

[1] A frog is same as No. 8.

ably be of first quality white oak, with a face of 8" and a depth of 6" ; to which dimensions they should be accurately sawed with faces at right angles. For a No. 8 frog they are 30 in number, with an additional one called the head block on which the switch gate and head chairs are fastened. This head block should have a face of 12", a depth of 10", with a length of 16' to accommodate gate.

The following bill gives number of pieces, with their dimensions:

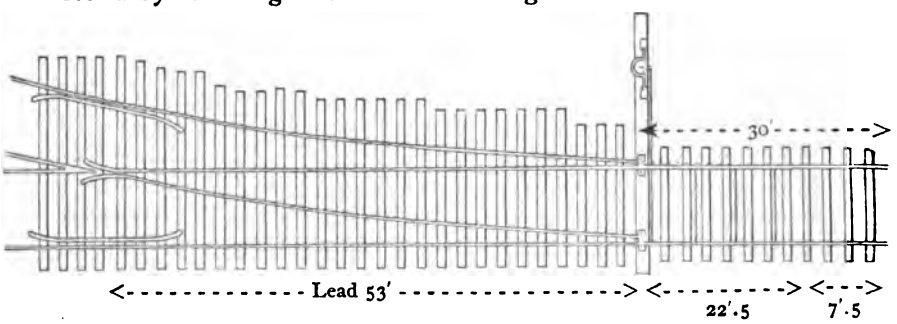
BILL OF SWITCH TIMBERS FOR NO. 8 FROG—4' 8½" GAUGE.

NO. OF PIECES.	DIMENSIONS.	LINEAL FEET.	FEET "B. M."
3	9' × 8" × 6"	27	108
7	10 × 8 × 6	70	280
6	11 × 8 × 6	66	264
5	12 × 8 × 6	60	240
4	13 × 8 × 6	52	208
5	14 × 8 × 6	70	280
30		345	1,380
1 Head Block.	16' × 12" × 10"	16	160

This set will answer for frog Nos. 7½ and 8½ as well as for No. 8. For higher or lower numbers slight and obvious changes are necessary.

Now comes the matter of locating switch and putting the above parts together. As a rule, the location of either head block or frog is fixed by some arbitrary or practical conditions, but in case where variation of a few feet can be allowed it is best to select some joint for either one end of the frog or for the toe of the moving rail. This saves one cutting of a rail. Having thus determined where the point is to come, we simply measure back the length of the lead as given in the seventh column of our table and obtain location of the head block. With that in position, the remaining ties are put in order at intervals of about 24 inches centre to centre, with the shorter timbers next to the head block. That permits 3 or 4 ties to be placed beyond frog point. The ends of the switch ties should be carefully lined on main track side so that gradual increase of length will serve on turnout side to accommodate curve. Now put in the frog. Inasmuch as it very rarely occurs to have two 30 ft. rails with their joints exactly opposite for moving rails,

it will generally be necessary to tear up main track and cut some rail so that two 30 ft. rails can be placed opposite each other for our moving rails. These (for a No. 8 frog), must be spiked for a distance of 7'.5 from the heel. The remaining 22'.5 are held together by the five switch rods previously described. With our frog and moving rails in position it is an easy matter to lay the lead and guard rails, put up the switch gate, and our switch is finished. Opposite the frog, on both main track and turnout, guard rails must be placed. The best length is about 15' with 2' at each end curved outwards from rail. Between the guard rail and main rail there should be a space of 2". Anything in excess of this will give a pair of wheels that chance to be wide gauge an opportunity to mount the frog point; and if the space is more than ¼" less than 2" the wheel flanges will rub. To obtain this distance of 2" the guard rail flange must be trimmed off ½", for unless this is done the spikes between guard and main rail will separate them at least 2½". Guard rails should not only be thoroughly spiked, but also have suitable braces on exterior to hold them firmly in position. Defective guard rails are frequent causes of derailments. The above arrangement can be more easily understood by referring to the annexed diagram.



Particular attention should be paid to the solid tamping of switch ties. The frog, and especially the lead rails, should be carefully lined, and in these points a track foreman can show his excellence. Many trackmen claim that the leads as given in the table are too short for practical purposes. This is not so, for if the lead is lengthened it is impossible to get a good line, an "elbow" being sure to occur between frog and head chair, and moreover when the moving rails are thrown for the side track the lead rails will not carry out the regular curve.

Mention was made above of spiking moving rails for a dis-

tance of 7.5′ in case of No. 8 frogs. Reference to our table will explain this. The lead of a No. 8 frog is seen to be 52.69′. Now that is from the theoretical point, but the actual point of the frog is blunt, being as a rule ½″ wide, hence in measuring from the actual point we must add ½″ × frog No., or 4″ for a No. 8 frog, to one lead length. So we get the convenient figure of 53′ for the lead distance, *actual* point to head block. Again we see that the total length of curve is 75.17′ and length of moving rail required 22.48′, these become 75.5′ and 22.5′ by adding our 4″ and taking convenient approximate numbers. So we have 22.5′ of moving rail unspiked, and with a 30′ rail 7.5′ spiked. One should carefully distinguish between theoretical and actual points, as calculations are based on former and measurements in practice on latter.

In cases where a transit is to be used, it must be set up at origin of our lead curve (point 0, Fig. 1) and lay off curve corresponding to frog with stakes at least every 25 ft. Then frog point will be in advance of this the number of feet taken from column 8 in our table; when the other distances can be measured back as before. So much for the ordinary "stub" switch. But on main lines, or where trains pass rapidly, the stub switch is an element of danger through misplacement, and our prominent roads have adopted some one of the patent safety switches for their standard. The principle of calculating lead, radii, etc., are of course similar to those of the stub switch, bearing in mind that in case of "point" switches the lead is the total distance as given in column 8, and means the measurement from frog point to switch point. The safety switches in most general use in this country are the Wharton, the Lorenz, and the Tracy. The first-named has the advantage of giving an unbroken main track, the wheels being carried over the rails. It has the disadvantage, however, of great weight and multiplicity of parts. The Lorenz is a "point" switch, and gives one main track rail unbroken. It is simpler than the Wharton, but has two serious disadvantages. Inasmuch as there are springs between the points, a derailment is almost sure to destroy them, or if ice and gravel get between point and main rail the target on the switch gate can be thrown to safety while the "point" has not moved, the lost motion being taken up by the springs. On a similar principle to the Lorenz is the Tracy, and I think the superior to them all. The spring is located in the switch gate and b··

an ingenious device the target cannot be thrown unless the point is securely in place. Its parts are few and in case of breakage can easily be duplicated at the R. R. Co.'s shops.

THE HANGING COMPASS AND ARC FOR MINE SURVEYING.

By THOS. H. LEGGETT, E.M.

IT is not generally known, I believe, what advantageous use may be made of the hanging compass and vertical arc in mine surveying, more especially here in Mexico, where one meets with old workings so confined and irregular that transit work is most slow and laborious, and at times next to impossible. It is of course necessary that there be no rails or other iron near to deflect the needle, but that again one does not find in opening up old works, and when these are once in a state to permit the use of tracks, there is no difficulty in using a transit.

That excellent work can be done with these little instruments I have had proven to me more than once; and perhaps an instance of my own experience with them may not prove uninteresting, as showing their utility. In a survey of the old Mexican mine of "San Joaquin de los Arrieros," made to gain an idea of the extent of the mine, and as an aid in forming a plan for its development, it was seen that communication could easily be made between certain points, establishing excellent ventilation.

Without going to the trouble of a special survey, the data for this were taken from this preliminary one, in which there were between the points to be connected 38 courses in all, of a total length of 1,127 feet, of which but one, 296 feet in length, was run with a transit, being on the surface of the hill between the two entrances to the workings.

In the hanging compass work the longest course was 69.3 feet, while several were but 6 and 7 feet long, the average length of the 37 courses necessary to cover 831 feet of workings being but 22.4 feet.

The difference in height between the tunnel entrances was 180 feet, and the necessary work for communication was the

sinking of a winze 19 feet and drifting 48 feet, the two faces meeting without any perceptible lateral difference, the floor of one drift being 6 inches above that of the other. This was more than sufficiently accurate for the required object, and satisfactorily proved, to myself at least, that with special care excellent results could have been obtained.

The method employed is to put in plugs, and nails in the same, along the walls of drift or shaft, and from these to stretch a stout string in continuous courses, running from side to side of the working to make each as long as possible. Two miners may precede one, putting in the plugs and stretching the string, which latter should be boiled in linseed oil and well waxed to prevent excessive stretching. Care is taken that the cord does not touch any projecting rock, and that after wrapping the nail its two branches intersect; also the vertical arc must always be hung in the exact centre of the course to allow for any sag of the string, however slight.

In Germany, the birthplace of this instrument, in place of the string, which necessitates the use of a steel tape, the practice is to use a very light brass chain or flexible wire, marked in fathoms, from which offset can be very readily taken by means of a rod in the hands of an assistant, and some very quick work done.

Breithaupt, of Cassel, Germany, makes a very fine instrument, put up in a light case that straps around the waist, compared with which that made by Brandis of New York is a most clumsy, inaccurate affair. The hanging compass is both lighter and better made, and the vertical arc is extremely light and is divided by means of concentric rings to 15′, while readings to 3′ may be accurately estimated, as the plumb-bob, which weighs about 13 grammes, is hung by a fine human hair.

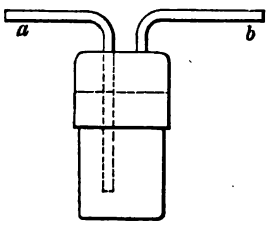
A COMBUSTION CRUCIBLE.

By A. P. HALLOCK, Ph.D.,

CHEMIST TO THE NEW YORK GAS WORKS.

HAVING a large number of combustions of anthracite coal to make, instead of burning them in a porcelain combustion tube I have employed the combustion crucible shown below, and have found that it gives very satisfactory results.

It consists of a small platinum crucible, about 3.5 cm. high and 2.0 cm. in diameter, provided with a cover which is ground to fit over the top so as to form a gas-tight joint. Through the top pass two small platinum tubes (*a* and *b*),



about 3 millimeters in diameter and 10 cm. long; (*a*) reaches nearly to the bottom of the crucible, while (*b*) only just passes through the top. On the ends of these tubes are soldered short pieces of glass tubing, having as nearly as possible the same coefficient of expansion as the platinum.

In making a combustion, .5 grm. of finely pulverized coal is weighed out and introduced into the crucible, with a small spiral of platinum wire to conduct the heat up through the coal. The cover is put on and the crucible attached to an aspirator in order to ascertain if the joint between the crucible and cover is air-tight. If found to be tight, the crucible is suspended by a platinum wire, and a tin plate having a hole in the centre a little larger than the crucible is placed around it to prevent the flame from heating the small tubes too hot.

The tube (*b*) is connected with the forward end of a glass combustion tube filled with oxide of copper heated to redness in a combustion furnace; to the other end of the combustion tube is attached the regular absorption tubes. After the oxide of copper has been heated red hot, a flame is applied to the bottom of the crucible and the crucible gently heated until red hot. Through (*a*) is then forced a slow stream of dry oxygen, and continued till the coal has been completely burned, after which the heat is slowly removed and the crucible allowed to cool. When cold, the contents are examined to see if any unburnt particles remain, if not, the ash is weighed, also the absorption tubes, and the results calculated as usual.

This little crucible is found to save both time and gas, for a combustion of anthracite coal does not require more than one fourth the time required to burn the same weight in a porcelain tube, besides permitting you to examine the ash before weighing the absorption tubes. As the oxide of copper tube does not need to be opened, it prevents any possibility of its absorbing moisture and giving too high results for hydrogen when only small percentages are present.

FRAME FOR LARGE BLUE PRINTS.

By W. B. PARSONS, Jr., C. E.

HAVING noticed in the April number of the Quarterly an abstract from a paper by Mr. Channing Whittaker on "Blue Printing," I send you a description of a device that I got up for the N. Y., L. E. and W. R. R. division office at Port Jervis, by which I overcame the difficulties incident to large glasses that Mr. W. speaks of. The glass was 58 inches long, 34 inches wide, and 3/8 inch thick. It was heavily framed with ash. In order to keep the back from warping out of shape, I had it made of thoroughly seasoned ash strips 1″ × 1″. Each strip was carefully planed, and then they were glued and screwed together, while across the ends were fastened strips with their grain running transversely. This back was then covered on side next to the glass with four thicknesses of common gray blanketing. Instead of applying the holding pressure by thumb cleats at the periphery, it was effected by two long pressure strips running across the back placed at about one quarter the length of the frame from the ends, and held by a screw at the centre. The ends of these strips were made so as to fit in slots in the frame at a slight angle, so that as the pressure strips were turned it gave them a binding pressure at the same time. In other words, it is the same principle as is commonly used to keep backs in small picture-frames. This arrangement, instead of holding the back at the edges only, and so allowing the centre to fall away from the glass, distributed it evenly over the whole surface and always kept it in position. The frame was run in and out of the printing room on a little railway on which it rested on four grooved brass sheaves, one pair being at one end, while the other was just beyond the centre, so the frame could be revolved in direction of its length without trouble. In order to raise the heavy back, I had a pulley-wheel fastened to the ceiling, through which a rope passed, with a ring that could be attached to a corresponding hook at the side of the back, in order to hoist it or lower it. Although that is an extremely large apparatus, yet by means of the above device it was worked easily and rapidly, and gave every satisfaction.

The solution used was of the same proportions as had been adopted in the other engineering offices of the road.

Citrate Iron and Ammonium . . . . . 1⅞ oz.
Red Prussiate Potash (C. P.) . . . . . 1¼ oz.

Dissolve separately in 4 oz. distilled water each, and mix when ready to use. But by putting mixture in dark bottle, and that in a tight box impervious to light, it can be kept two or three weeks.

[In some frames used at the School of Mines for making large blue prints a similar device has been in use for several years. Instead, however, of the heavy and cumbrous back used by Mr. Parsons, a light, somewhat flexible back of one quarter inch pine is employed, covered with heavy Canton flannel, and several thicknesses of newspaper. The pressure is applied by light pressure strips of ash somewhat thicker at the middle than at the ends, which give a fairly uniform pressure across the width of the frame sufficient to hold the back firmly against the glass at all points. This system has been used with success for frames twenty-seven by forty-two inches, about half as large as the one described by Mr. Parsons. A frame of this size can be easily handled without mechanical aids. Care should be taken to avoid too great thickness and too much spring in the pressure strips, or the plate glass may be broken by excessive pressure. The strips used are about five-eighths of an inch thick at the middle, and taper to about three-eighths of an inch at the ends.

The formulæ for the solution given by Whittaker, Laudy, and Parsons are practically identical so far as the proportions of citrate of iron and ammonia and of red prussiate of potash, 3 of the former to 2 of the latter, but differ in the amount of water. Laudy's formula calls for about 5 parts of water to 1 of the salts. Whittaker's for 4 parts, and Parsons' for a little more than 2 parts. The stronger the solution the longer the exposure required. With very strong solutions a large portion of the Prussian blue formed comes off in the wash-water, and when printing from glass negatives the fine lines and lighter tints are apt to suffer. The blue color, however, will be deep and the whites clear. With weak solutions the blues will be fainter and the whites bluish. Heavily sized paper gives the best results. The addition of a little mucilage to the solution is sometimes an advantage, producing the same results as strength of solution, by increasing the amount adhering to the paper. With paper deficient in sizing the mucilage also makes the whites clearer. H. S. M.]

PROFESSIONAL NOTES.

Civil Engineering.

*Most Economical Height of Bridge Truss.**—In cases where the height of a bridge truss is not fixed by some condition, such as head room, it is generally determined by copying some existing bridge and made an eighth or a tenth of the span, without considering the relative economy. For a given span, style of truss, number of panels, and load, there is a certain height of truss which will require the least material, and is therefore the cheapest. To find this height the author gets an expression for the amount of material in a half truss by adding the amount required in each member according to the strains to which it is subjected. This is multiplied by the price per cubic inch of iron, or wood. This given an equation of the form,

$$v = \frac{a}{m} + bm + cm^3,$$

in which a, b, and c are constants representing the cost of the material and m is the ratio between the length and height of the panel. From this the value of m corresponding to a minimum value of v is easily found by putting the second differential coefficient equal zero, etc.

The example of a Howe truss is given in which the number of panels is 12, length of each panel 120 inches, the least dimension of the compression braces, as calculated by Gordon's formula, is 8 inches, the least dimension of the upper chord is 11 inches, price of iron 5 cents per pound, and of wood $27 per 1,000 feet; the permanent load on each panel 6,704 pounds, and the variable load 16,800. The value of m found to be .96, *i.e.*, the height of a panel equal .96 times the length, gives as the cost of a half truss $342.89. If the number of panels be taken at 6, the span and load being the same, m is found to be .72, and the cost of a half truss $501.78. If in the last case we have 12 inches instead of 8 in the braces, and 20 inches instead of 11 in the upper chord, m equals .73 and the cost of a half truss is $310.33, which shows the result of using pieces of large diameter in the compression members.

The application of this method to a Pratt and a Warren truss, each of 515 feet span and equally loaded, shows the amount of material required by the Warren truss to be 426 tons, and by the Pratt 409 tons. Each truss has 20 panels, a permanent load of 5,400 lbs. per lineal foot and variable load of 1,818 lbs. The difference is probably due to the fact that the posts in the Pratt truss are vertical and therefore shorter than those in the other. F. P.

* Abstract of paper by T. M. Cleeman, Proceedings of Engineers' Club of Phil., Dec. 1882.

Naval Engineer A. Y. Menocal describes his work at the Gosport Navy Yard in a late issue of the Transactions of the A. S. C. E. The quay wall had begun to weaken and settle. It was of cut granite laid on a timber platform carrying foundation piles. These piles, owing to the devastation of the teredo and some dredging operations carried on to deepen the channel in front of the quay, had yielded, and hence the trouble. A method of underpinning was adopted, as the total destruction and rebuilding of the pier was out of the question on account of cost. Sections of 6 ft. of the support of the wall were removed by divers; the piles capped in offsets in the direction of the width of the wall, and bags of concrete introduced. Sections of the wall at some distance apart were thus underpinned and then the gaps filled. The entire settling was $7\frac{7}{8}$".

Cost of work, $125.10 per lineal foot. Depth of water at quay 21 ft. 6 in. To remove the broken capping mixed with stone and mud, a jet from a hose and steam pump was used. The wall was well shored up during the entire operation, and no subsidence has been noticed since.

K. N.

A. P. Boller lately described before the A. S. C. E., an ingenious method for overcoming the difficulties incidental to replacing the masonry piers of the Croton Lake bridge of the New York and Northern R. R. These piers are of masonry, supported by plank cribs running up to low water with an outside protection of ripraps. On the top of these masonry piers rested the iron piers or tower which supported the main girders. Owing to the depth of water it was impossible to stage along the length of the bridge. The method employed was as follows: Straight piers of wood (all pieces in pairs) were placed inside of the iron ones and raised by hydraulic jacks. Once raised the iron piers were hung from 15"–200 lbs. per yd. beams supported near the centre of the masonry and at the outside edge of the crib by timbers laid on the crib. The structure being thus supported, the masonry was easily removed and replaced and the structure then again lowered. There was no interference with the running of the trains during the entire operation. The principal difficulty to be overcome was to replace the masonry immediately under the points of pressure of the iron piers.

K. N.

For the past few years much annoyance has been caused in Halifax, owing to the gradual diminution of the water supply from some unknown cause. Upon examining the interior of the water mains it was found that they were filled almost entirely with a deposit of oxide of iron. Attempts were made to scrape this out by hand, but the extent of the work was large and the progress slow. Finally a method was adopted which entirely removed the deposit and enabled the mains to be kept clean.

A device is employed called a scraper, consisting of a stout wrought iron rod jointed at the middle so as to enable it to pass ordinary curves. Eight spring steel arms press against the pipe and are arranged in sets of four, so that any deposit escaping the front set will be removed by the second. These arms have a barbed cutter attached, and vary in size according to the diameter of the pipe.

The arms yield inward, should any obstruction be met. The machine is propelled forward by two pistons of rubber, which are so held as to yield backward and pass any prominence left by the arms. Steel springs maintain the machine in the centre of the pipe.

The machine travels through the pipe at various rates according to the amount of incrustration, three miles an hour being the best record for a long run. The cost of the work has been but slight in comparison to hand-work, and the efficiency of the water work greatly increased—in fact they were steadily becoming useless. [For details, see E. H. Keating's paper in Transactions A. S. C. E., Vol. VI., p. 127.]

K. N.

Field Application of Equation for Curvature.—Abstract of Paper by W. C. Wetherill, Proceedings of Engineers' Club of Philadelphia, Dec., 1882:

In running a preliminary line it is exceedingly desirable to have it coincide as nearly as possible with the final equated location. It is a well known fact that if the rate of equation in feet per degree of curvature per station of 100 feet, be multiplied by the intersection angle of any curve in degrees and decimals, the product will be the vertical reduction in grade upon that curve, no matter what the radius. Since this is true, it follows that if, in running a preliminary line, each angle turned be multiplied by the proposed rate of equation, and the grade on the profile raised or lowered by their product, thus making a vertical step in the grade at each angle turned, the result will be a very close approximation to the located grade.

Another question that frequently occurs in practice is how to determine the exact rate of tangent grade that must be adopted to connect fixed points, as a summit and a river crossing. Denote the sum of the intersective angles in degrees and decimals by I, the total rise or fall by R, total length of line in stations of 100 feet by L, the rate of equation per degree of curvature per station by E, and the requisite rate of tangent grade by X. From what has been stated it is evident that

$$R = (X \times L) - (I \times E).$$

Hence,

$$X = \frac{(I \times E) + R}{L}.$$

—F. P.

Mining Engineering.

Poetsch Method of Sinking in Quicksand by Freezing.—The proposal has been recently made by Poetsch in Germany, to facilitate the sinking through quicksand by freezing the ground. Professor G. Koehler, of the School of Mines at Clausthal, has given the details.

The Poetsch method, which many experts think will rank among the best means of getting through ground of that character is the following: After he has reached the quicksand in the ordinary way, he puts down a number of holes, three feet apart in a circle, through the layers of quicksand, at such an angle that they reach into the ground through which the shaft must pass. Further, a smaller circle of holes is put down in the bottom of the shaft and one in its centre. All of the holes are sunk by means of a sand pump, being tubed as they go down. A circular distributing-pipe is suspended above the bottom of the shaft, copper tubes provided with cocks connecting with each of the holes and descending in them to their bottom. Through these copper tubes he pumps

into the holes a solution of calcium and magnesium chlorides reduced to a temperature of 25 degrees Celsius below zero. The solution flows to the bottom of the holes and ascends in them in the annular space, being gathered as it reaches the top of the holes by a collecting pipe. It took from 10 to 14 days to freeze a deposit of 12 feet of quicksand into a solid mass of ice, through which sinking may go on without any danger of accidents from water.—*E. M. Journal, Oct.* 21, 1883.

W. F. M.

Metallurgy.

Basic Process at Creusot.—The basic Bessemer converters at Creusot are lined with a dolomite containing 53 per cent. of lime, 35.80 of magnesia, and 7.70 of silica and alumina. This is heated to redness, quickly pulverized, mixed with 10 to 15 per cent. of tar, and stamped in with heated iron stampers. The tuyeres are made of silicious material. The converter is charged with 16 to 18 per cent. of heated lime and about 1½ per cent. of fluor spar, and is then charged with 8 tons of cast iron taken directly from the blast furnace. After slagging and decarburation, the overblow and recarburation is effected with spiegeleisen containing about 18 per cent. of manganese. The bottom requires repairs after 15 to 20 charges. The sides require renewing after 80 to 100. The cast iron contains carbon, 3; silicon, 1.3; manganese, 1.5 to 2; phosphorus, 2.5 to 3; sulphur, not more than 0.2. The steel produced contains 0.01 to 0.02 of manganese, and 0.03 of sulphur. The slag at the end of the decarburation contains 22 per cent. silica, 12 per cent. phos. acid. At the overblow they contain 12 per cent. silica, 16 per cent. phos. acid. The steel made by the acid process contains considerable silicon, which is often greater in quantity than the carbon. The quantity of phos., sulph., and silicon is less in the basic steel, and the quantity of carbon higher. The quantity of manganese is considerably less. The following is an average analysis of the steel:

	BASIC.	ACID.
Carbon	0.43	0.40
Silicon	trace	0.30
Phosphorus	0.06	0.075
Sulphur	0.029	0.040
Manganese	0.76	0.66
Tensile strain per sq. m.m.	72 kilos.	73.2 kilos.
Percentage of stretch	16.1	17.2

—*Berg & Hutten, Män. Zeit*, 1883, p. 131.

T. E.

Open Hearth Dephosphorization at Creusot.—The hearth is made of the same dolomite as in the converter. The arch is made of silica brick, which is separated from the basic material by a layer of bauxite. The charge of cast iron containing phosphorus is mixed with wrought iron, which is added little by little. Three to four additions of lime are made and the slag withdrawn from time to time. As soon as a breaking test shows the dephosphorization finished, the recarburation with spiegel begins. The comparison of this work with that of the converter shows that the introduction and repairs to the basic lining are easier in the furnace; that as the highest temperature is arrived at immediately after the combustion of the carbon and silicon, no attention need be paid to the other foreign constituents in the iron. The slags can be easily withdrawn from the furnace; while in the converter to effect it

the slags must be very fluid. The dephosphorization commences at once, and there is no fear that after the addition of the spiegel a reduction of the phosphoric acid will take place. As the process takes a longer time, the mechanical tests can be more carefully made.

An open hearth steel of this kind contains—

Carbon	0.16
Silicon	trace
Sulphur	0.03
Phosphorus	0.03
Manganese	0.25

The steels are better and more uniform in quality than those made in the converter, and the composition more uniform. The physical and mechanical tests are, however, alike. In order to prevent blow holes, the temperature is raised at the time of casting.—*Berg & Hutten, Männische Zeit.*, 1883, p. 132. T. E.

Lead Smelting by Roasting and Reaction, at Viallas.—The ore comes from a series of veins which have been worked for more than a hundred years. As they come from the mine they are classified into rich ores, which contain 60 per cent. of lead and 500 grams of silver to the hundred kilos.; medium ores, which contain 35 per cent. of lead and 490 grams of silver to 100 kilograms; poor ores, containing 7 per cent. of lead and 375 grams of silver to the hundred kilograms; and fine ores, containing 4½ per cent. of lead, and 380 grams to the hundred kilograms.

The last three classes of ores are enriched by mechanical preparation. The loss has been found to be 25 per cent. of the lead, and 15 to 16 per cent. of the silver contained. The rich and dressed ores are roasted and agglomerated in a reverberatory furnace, and the product smelted in a low shaft furnace. The lead resulting is either cupelled and a salable litharge is made, or it is treated by zinc desilverization.

The roasting is done in a reverberatory furnace heated with coal, the charge being 900 kilograms. It is first roasted carefully to drive off the sulphur, and is then treated at a high heat to form a silicate of lead. In the first period the ore, which is galena mixed with iron pyrites, sphalerite, siderite, carbonate of lime, sulphate of baryta, quartz, and some mica schists, is transformed into oxides, and in the second part these are melted, the workmen stirring the whole melted bath carefully in order to make all the silica, both that which is free and that in the mica schist, act on the metallic sulphates and on the sulphate of baryta. The result is a more or less well defined silicate of lead which is very poor in sulphur. The process is so conducted that while decomposing the sulphates the temperature is kept at such a point that the product will be porous. The ore which is treated in this way has the following composition:

Oxide of lead	52.24
Oxide of antimony	0.69
Oxide of zinc	2.13
Oxide of copper	trace
Sulphuric acid	3.61
Silica and sulphate of baryta	19.44
Oxide of iron and alumina	18.94
Lime	1.29
Magnesia	1.37
	99.71

Condensing chambers are attached to all the roasting furnaces. The silicate, allowed to cool, is broken and carried to shaft furnaces, which are 1.70 meters high, having a rectangular section of .50 m. by .90 m. They have four tuyeres—two on each of the long sides. They are built of refractory brick and have large fore hearths. The slags run over the fore hearth nearly continuously. The lead is tapped three times in a shift of eight hours from the tap hole at the bottom of the crucible, which is closed with brasque. The charge is prepared on the charging floor at the top of the furnace, and has the following composition :

Roasted ore	100
Poor lead slags	50
Iron reheating cinder	15
Cupel bottoms or other materials containing lead	10

The cupel bottoms have the following composition :

Oxide of lead	78.54
Oxide of antimony	0.21
Oxide of zinc	0.24
Silica and insoluble matter	4.76
Oxide of iron and alumina	2.01
Lime	7.43
Magnesia	97.80

The lead scorias added to the fusion bed facilitate the reactions in the crucible by making the fused material more liquid, and thus producing an intimate contact of the elements. The reheating scorias saturate the silica of the ore, and as the silicate of lead is of very unstable composition, and as it furnishes various basic elements, such as lime, magnesia, baryta and oxide of iron, the scorias from this treatment are quite liquid and are very poor in lead. The descent of the charge is very rapid ; the reactions take place in the zone of fusion and in the crucible. Eight thousand kilograms of ore are easily smelted in 24 hours.

The coke is hard, and specially made for metallurgical purposes. The zone of fusion is very limited. The throat is black during nearly the whole of the campaign, which does not generally last more than 7 or 8 days. No loupes are formed in the furnace, and the working is generally very regular. Mattes are only formed occasionally, and when the charge has been badly prepared.

The scorias generally contain 33 per cent. of silica, less than three grams to the 100 kilograms of silver. The lead contained in them, determined in the dry way, is rarely one per cent., and is generally less than half of one per cent. The fusion in the shaft furnace gives a work lead containing the silver, and besides some few secondary products, such as dust and débris of furnaces, which are passed again in the treatment. The dust is collected from the condensation chambers at the end of a campaign. It has a mean composition of

Oxide of lead	36.49
Oxide of antimony	1.29
Oxide of zinc	3.31
Sulphuric acid	13.16
Sulphur	2.93
Silica and sulphate of baryta	21.40
Oxide of iron and alumina	10.19
Lime	7.94
Magnesia	1.74

The total losses in the treatment, as determined on a trial of ore containing 177.522 kilos. lead and 792.676 kilos. of silver, which yielded 791.726 kilos. of silver and 160.583 kilos. of lead or litharges, are shown to be almost nothing on the silver and not more than ten per cent. on the lead.—*Bulletin de la Société d'Industrie Minérale, 2 S. vol.* 11.

T. E.

Engineering and Mining Journal, Sept., 1883.—Carl Henrich, in a communication to the "Engineering and Mining Journal," gives the results of an experiment in the smelting of Anglesite in Arizona. The reaction theoretically desired is expressed by the formula :

$$SiO_2 + 2FeS_2 + 5PbSO_4 = 2FeO, 2SiO_2 + 9SO_2 + 5Pb.$$

Theoretically the amount of fuel necessary will be a minimum, as the work of reduction is done by the sulphur and iron of the pyrites, and the fuel is only necessary to raise and maintain the temperature to the degree at which the reaction will proceed.

The practical working of the furnace showed this to be true, and the amount of fuel had to be somewhat reduced in consequence.

J. B. M.

O. H. HAHN, in a paper entitled "The Smelting of Argentiferous Lead in the far West,"* gives some data regarding metallurgical practice in Utah. Sulphuretted, arsenical, and antimonial ores are roasted in long reverberatory furnaces, from 30 to 40 feet long and 10 to 12 feet wide, being divided into four or five hearths. When the roasting is finished the charge should be fused or agglomerated, in order to facilitate the subsequent smelting. In the case of copper-bearing ores, enough sulphur must be present in the smelting mixture to form a copper matte.

The roasted ore, agglomerated flue dust, and raw oxidized ores, are smelted with addition of the proper fluxes, in shaft furnaces using coke or charcoal. The furnaces furnishing the best results are of the Rachette type, since the capacity of this type of furnace may be increased largely without increasing the blast pressure, by simply extending the length while the width and height remain unchanged. The Piltz furnaces and others of circular section, on the other hand, cannot be increased in capacity without a corresponding increase in height and blast pressure. The furnaces are provided with water jackets and dust chambers. The slag is tapped intermittently. The tuyeres are 10 inches above the top of the hearth, and are employed in the proportion of one of 3-inch opening per 2 square feet of hearth area. The ordinary blast pressure is about half a pound per square inch.

The water jackets used by Mr. Eilers are 3½ feet high, with tuyere openings cast in them 10 inches from the bottom. They have a projecting lip at the top, 4 inches higher than the rest, which is left open, and which serves for the introduction and overflow of the water, and prevents the accumulation of air or steam.

The slag which it is the aim of the metallurgist to produce, naturally depends on the ores and fluxes which are available. The oxygen ratio of bases to acid should be 1 : 1, forming a singulo-silicate. Other things being equal, a slag of the formula $3(2FeO,SiO_2) + 2(2CaO,SiO_2)$ furnishes the best results. "Running on such a slag a furnace can never

* *Mineral Resources of the United States* (U. S. Geological Survey).

get out of order except through gross carelessness." When there is an excess of iron in the ore, a slag of the formula $3(2FeO,SiO_2) + 1(2CaO,SiO_2)$ works very well, and is very suitable for zinciferous ores. If the proportion of iron to lime be increased beyond this point, oxides of lead and silver will enter the slag. Alumina requires an equivalent amount of silica. An aluminous slag from the Horn Silver Works has the composition $3(2FeO,SiO_2) + 4(2CaO,2SiO_2) + (Al_2O_3,3SiO_2)$. Manganese may replace iron; and magnesia, baryta, and strontia may replace lime.

The products of the smelting process are metallic lead carrying gold and silver, mattes, speiss, slag, and flue dust. The speiss is not worked anywhere in the United States. Mattes from zinciferous ores are of low specific gravity, and remain entangled in the slag. By the addition of copper-bearing ores the specific gravity of the matte is increased, causing a cleaner separation. J. B. M.

Electricity.

Bulletin de la Soc. Chem. de Paris, 1883, *V.* 40, p. 173.—Messrs. Lalande & Chaperon have constructed a new form of electric battery. The positive pole is iron surrounded with oxide of copper, the negative pole amalgamated zinc, the exciting liquid a 30% to 40% caustic potash solution.

When the cell is in action the zinc dissolves in the potash, setting free hydrogen, which reduces the oxide of copper to the metallic state. There is no action when the circuit is open. Care must be taken to prevent the absorption of carbonic acid from the air, either by an air-tight cover or by a film of petroleum floating on the surface.

The E. M. F. is about 1 volt, the resistance is about $\frac{1}{8}$ to $\frac{1}{4}$ ohm for opposed surfaces of one square decimeter, at a distance from each other of 5 centimeters.

The oxide of copper may be molded into blocks, by making it into paste with oxychloride of magnesium. J. B. M.

Chemistry.

Copper Sulphide in a Colloidal Condition.—Mr. W. Spring has found copper sulphide is completely soluble in pure water when prepared in the following manner: Hydrogen sulphide is passed into a dilute solution of copper sulphate in ammonia. The precipitate is washed with sulphuretted hydrogen water for a long time. As soon as all the ammonium sulphate is removed the sulphide of copper goes into solution. —*Chemical News, Aug.* 1883, p. 101. C. McL.

Titanium.—A. Weller has proposed a method for estimating titanium by a colorimetric test with hydrogen peroxide. The presence of the metal may be detected in a sulphuric acid solution of $\frac{1}{50}$ of a milligram, by the production of an orange-red color on the addition of a few drops of peroxide. Vanadic and molybdic acids as well as iron salts, must be removed before applying the test. Niobium, tantalum, and zirconium do not interfere.—*Amer. Chem. Journal, Vol. V.* p. 122. C. McL.

Determination of Boracic Acid Volumetrically.—Mr. Edgar F. Smith has recently published a method for the determination of boracic acid vol-

umetrically. The principle involved is the precipitation of the acid, as manganese borate, MnB_4O_7 from an alcoholic solution by manganese sulphate. The determination is conducted in the following manner: An excess of a standard solution of manganese sulphate is added to the fluid containing the boracic acid. An equal volume of strong alcohol is then introduced, and, the whole being thoroughly mixed, is allowed to stand for half an hour. The precipitate is filtered off rapidly and washed with alcohol. The filtrate and washings are evaporated to dryness. Finally the excess of manganese is determined according to Volhard's method. Insoluble borates (tourmaline, etc.,) are pulverized and fused with a known amount of sodium carbonate. The fused mass is extracted with water. Lastly, an amount of ammonium sulphate, molecularly equivalent to the sodium carbonate, is added to the filtrate to separate any silica or alumina which may be present. The filtrate and washings, after concentration, are treated with the manganese sulphate solution as before. In a number of experiments made by Mr. Smith, the results obtained were very satisfactory, the greatest error being forty-four hundredths of one per cent.—*Am. Chem. Journal, Vol. IV.* p. 279. C. McL.

Zeit. für Anal. Chem. 1883—W. Fresenius has found a hitherto unsuspected source of error in the determination of arsenic. He finds that many samples of glass contain arsenic which under some circumstances may be set free and mislead the analyst.

When an alkaline flux is melted in contact with an arseniferous glass, either in a current of carbonic acid or hydrogen, the arsenic will be set free. By the reducing action of hydrogen alone the amount set free is very small. If a solution of an alkaline carbonate be boiled in a vessel of such glass, a very perceptible amount of arsenic will be taken into solution, while, on the other hand, hydrochlorci acid solutions have no solvent effect. The glass used in the above experiments contained 0.20 per cent. arsenic J. B. M.

Zeit. f. Anal. Chem., 1883.—W. Knop separates potash and soda from iron, alumina, lime and magnesia in silicates, by treating the substance (with addition of silica, if necessary) with a mixture of one part hydrochloric and two parts hydrofluoric acid. On evaporation to dryness the fluosilicates of potash and soda, and the chlorides of iron, aluminium, calcium and magnesium remain. The residue is redissolved in a little hydrochloric acid, some alcohol is added, and after some time an excess of ether. The fluosilicates of the alkalies are now precipitated, while the major part of the chlorides of the other bases remain in solution. The precipitate is ignited, transformed into bisulphates, treated with ammonia and ammonic carbonate, and the silica and bases present filtered out, leaving the alkaline sulphates and ammonic sulphate in solution. J. B. M.

Moniteur Scientifique (3 Ser.) 12, 781.—A. Guyard prepares oxygen at the ordinary temperature by the action of concentrated nitric acid on potassic permanganate. When the evolution slackens, the flask may be gently heated, when a further quantity of gas will be obtained.

J. B. M.

Filter paper free from ash is now prepared by Messrs. Carl Schleicher & Schüll. The mineral constituents are removed by treatment with hydrofluoric and hydrochloric acids. The paper filters rapidly, and is quite strong, and from our own experience we can highly recommend it to our chemical readers. The ash of a filter 7 c.m. in diameter is $\frac{1}{100}$ of 1 milligram. J. B. M.

Ber. d. deutsch. chem. Gesellschaft. z. Berlin. 14. 2085.—August Harding describes a method for the preparation of hydrobromic acid, and its uses in analytical chemistry. Bromine vapor mixed with hydrogen is passed over red-hot platinum, the resulting hydrobromic acid, with excess of bromine or hydrogen, is washed with water, passed through a tube filled with metallic antimony to remove any free bromine, and then condensed in water. The joints of the apparatus which are exposed to brominevapors must be made of glass-wool, asbestos, or some material which will not be attacked.

Hydrobromic acid dissolves all simple sulphides, it converts sulphur in contact with amalgamated copper into sulphuretted hydrogen, and easily dissolves metallic copper, mercury, and lead. J. B. M.

Monatshefte für Chemie, 3. 249.—B. Reinitzer. Chromium acetate in the presence of iron or aluminium acetates will prevent their complete precipitation as basic acetates on boiling. The acetates of iron, aluminium and chromium remaining in solution cannot be precipitated by the ordinary alkaline reagents. It follows that, in presence of chromium, iron and aluminium cannot be separated as basic acetates, as in the ordinary course of analysis. J. B. M.

An Introduction to the Study of Organic Chemistry. By ADOLPH PINNER, Ph.D., Berlin University. Translated and revised from the fifth German edition by Peter T. Austen, Ph.D., F. C. S. New York: John Wiley & Sons. 1883. $2.50.

Under the above title Prof. Austen of Rutgers College has presented a very able translation of Adolf Pinner's "Repetitorium der Organischen Chemie"—a book that has experienced five editions in somewhat less than ten years. This fact certainly speaks well as to its merits.

The general treatment of the subject is founded on the system of Prof. A. W. Hofmann, in fact—as the translator remarks in his preface—it "in some cases follows his lectures quite closely."

It is certainly a matter of no slight difficulty to prepare a plan of the vast structure of Organic Chemistry that shall secure for the student entering upon this study a general conception of the whole, and, at the same time, enable him to understand and appreciate the value of the component parts.

The system of classification underlying the present work, certainly tends in a great measure toward this end.

Following the Introduction—which embraces a brief glance at the methods of organic analysis, the calculation of molecular weight, quantivalence, substitution and isomerism—is placed the Fatty Group.

The Fatty Group is divided into six divisions:

The Mono-carbon Group.

" Di- " "

The Tri-carbon Group
" Tetra- " "
" Penta- " "
" Hexa- " "

In each of these groups there is discussed, first, the starting-point of that group: thus in the C_1 group, methane; in the C_2 group, ethane, etc. Then follow the substitution-products by hydroxyl, sulphur, nitrogen, phosphorus, etc.

After these have been disposed of, and a few words devoted to some members of the higher carbon groups, the fats, carbhydrates, and uric acid, with derivatives, are noticed.

A retrospect of the principal classes follows—arranged, not according to the carbon series, but according to the nature of the substitution—a valuable chapter.

The Aromatic group, which receives attention next, after some general remarks relating to the constitution of the benzol nucleus, etc., takes up in succession Benzine, Toluene, Xylene, etc., and derivatives, and then proceeds to the Indigo-group, Diphenyl, Fluorene. A retrospect follows, and then come Naphthalene, Phenanthene, Anthracene, etc.

The camphors, essential oils, resins, pyridine bases, the alkaloids, glucosides, etc., are considered in separate groups. The Appendix includes, more in detail, methods of organic analysis, determination of vapor-densities, synthetic method of determining the constitution of compounds, and a brief mention of the phenomenon of atomic migration.

This is the broad outline of the ground covered, and the system adopted in so doing.

The work certainly possesses many excellent features. However, whether it might not be rendered still more serviceable as a text-book—the chief aim in view—by certain alterations, remains an open question.

The number of formulæ given might be decreased without material injury to the book, or the spirit in which it is conceived, and as a text-book, its value would undoubtedly be greatly enhanced if a glossary of such terms as ketones, quinones, alcohols, etc., were added.

Judging from the general arrangement of the American edition, it appears doubtful whether Naphthalene, Anthracene, etc., are intended to be classed in under the Aromatic Compounds, or not, as the title "Aromatic Compounds" is discontinued on the pages where these bodies are under consideration.

Apart from these points, however, the book bears testimony to conscientious labor expended in its preparation, and it is to be hoped that it may meet with the approval it deserves.

American Chemical Journal, Vol. V.—Messrs. F. W. Clarke and E. A. Kebler have found that cadmium iodide exists in two allotropic forms, α. and β., of specific gravity 5.644 and 4.626 respectively.

The α modification is the normal variety, is white and is not affected by heating below 250°. The β salt was formed when cadmium was dissolved in hydriodic acid, or when the acid solution of the α salt was treated with metallic cadmium. The authors suggest that nascent hydrogen perhaps determines the change. The β salt is brownish, and

by heat is transformed into the α modification, suffering partial decomposition at the same time. J. B. M.

Mechanical Engineering.

The autumn meeting of the American Society of Mechanical Engineers was held in New York, November 1st to 3d. The attendance was large, the meetings were interesting, and the papers of value. Mr. Pickering, who has represented the United States as commissioner for nearly all the international exhibitions, presented a paper embodying his suggestions and experience in reference to American machinery at foreign exhibitions. There were many striking reminiscences brought up among them, recalling how American exhibitors at one time could only prevent their exhibits from being uncovered on Sunday by actually sitting on the protecting covers; how it was thought best that the American machinery section should be driven by a foreign engine, on the plea that the foreign engine could do it better than one sent from here! There was considerable interest and amusement created when Mr. Hobbs, celebrated as the picker of the challenge Bramah lock of English make, was induced to tell the story of that feat and of several others of a kindred kind in which he had figured as expert. Professor Egleston presented a paper describing a machine he has devised for investigating the abrasive resistance of metals. He proposed a scale of hardness graduated with reference to known standards, and showed that spots of unequal resistance in a sample may be detected by observing the unequal indications of registers connected with revolving drills whose points are of known hardness. In the discussion which followed, some very interesting points were brought out in the matter of brass alloys, their fatigue and disintegration, and anomalies in their manufacture. A paper on a tilting water meter brought out the point that piston meters for water flowing at low speeds, or for water which is gritty or carries much mud or sediment, are liable to very serious error. The design proposed was an improvement upon the old meter which early graduates will recall in the private laboratory of the Professor of Chemistry in the School of Mines. An electric recording attachment, to tally the number of oscillations of the measuring cup, makes such an instrument a convenient check upon the weighed feed-water of a boiler test. A power crane was described in the next paper, the principal feature being its simplicity. The power from a countershaft was taken by bevel-gear to a screw in the same line as the pivots around which the crane turned. This screw carried a nut whose motion up and down lifted the load by chain. A paper on a new valve motion for steam engines was illustrated by a neat model now in the custody of the Engineering Department of the School. A paper on the "Power Developed under the Drop Press," brought out the very high efficiency of that form of shaping device, and elicited discussion on rapidity of "flow" in different metals, and the relative efficiency of heavy and light hammers and drops. A paper entitled "Shop Algebra" presented the method of making one drawing answer for many sizes of a single shape by the use of letters and symbols on a single drawing, accompanied by a table giving the values of the symbols in the different sizes. This plan has been objected to on the ground that a workman in reading a drawing will make all the mistakes there are excuses for, and this system opens

a wider field than the thoroughly figured drawing does. Much interest arose about a paper on the efficiency of a number of coverings for steam pipes to prevent losses by radiation and condensation. A large number of those sold in the market were tested, and a number were made up and tested, and the results tabulated. These will be presented in due time. The use of plaster of paris and sawdust by the Calumet and Hecla mine as a non-conductor was referred to, and the results of exposure of steam pipes in low temperatures were presented. Other papers were read by title only, to appear in the Transactions.

Besides the professional papers, the Society enjoyed two excursions. One was to the Yale & Towne Manufacturing Co. at Stamford, Conn., where the manufacture of the Weston pulley blocks, the Yale locks, the Weston-Capen travelling cranes, and the Emery testing machines are carried on. The Society saw several specimens tested on a machine of 151,000 pounds capacity. The other excursion was tendered by the N. Y. W. S. & B. R. R. over their line to Kingston, N. Y., and return. Opportunities were given to see the interesting tunnels, bridges, and the great Rondout viaduct on this line; but after all, the great advantage was the chance for professional conferences which such an all-day trip both allows and provokes, where older men tell the younger of the experiences which have been invaluable to them. The meeting broke up late on Saturday, Nov. 3d. The next meeting will be held in the spring at a date hereafter to be fixed. F. R. H.

SURVEYING.

Davies' Surveying. Revised by Prof. J. H. Van Amringe. Published by A. S. Barnes & Co., N. Y. City.

The revision and additions made to this standard work make it the best text book and practical manual on surveying before thep ublic. We notice with pleasure the introduction of Davis' formulæ on earth work, etc. The chapter on the variation of the compass is rendered exceedingly valuable by the introduction of the standard results of the U. S. Coast and Geodetic Survey.

We are glad to see in the work illustrations of the cross sections of the instruments, as such pictures are far more instructive than any perspective view. The chapter on Mine Surveying is especially well treated, and furnishes just the information needed by the young mining engineer.

The valuable appendices treat of the "Solar Compass," "The Sextant," and give a copy of the "Instructions to the U.S. Mineral Surveyors."

The book will become, we have no doubt, a *vade mecum* to every surveyor and engineer.

SCHOOL OF MINES NOTES.

ADDITIONS AND IMPROVEMENTS IN THE ASSAY LABORATORY.

AMONG the recent changes and improvements in the School of Mines, the introduction of machinery for practically testing and treating the ores of the precious metals may be noted. The erection of the new building on Fourth Avenue having made it possible to enlarge the assay laboratory, room was set apart for this purpose, and we understand that Dr. Ricketts is making active preparations to place therein the necessary machinery, such as crusher, rolls, stamp-mill, pans, concentrators, etc. It was the intention to have the plant in operation this winter, but the unfinished condition of the building has prevented. The next number of the QUARTERLY will contain a full description of the plant and the method of instruction adopted. P. de P. R.

LIGHTING COLUMBIA COLLEGE LIBRARY BY ELECTRICITY.

RECENT advices have confirmed the rumor that it is proposed to light the new library building by incandescent electric lights. The project involves erecting a dynamo in the engine-vault, adjacent to the boiler-house and carrying the wires through the library hall. The present Buckeye engine is rather small, and is likely to be replaced by an engine of larger size and arranged with automatic cut-off, to allow for the varying resistance offered by varying numbers of lights. The present engine was put in to meet a constant resistance only, and has only a throttling governor. One system of lighting proposed embraces the use of upright standards on the railing of the gallery, and bracket-arms from the gallery floor with shades to throw the light down. In addition, it has been proposed to have movable standards for use on the tables, the two wires being brought down together from above. Another system, offering less advantages, involves the use of several electroliers pendent in the centre of the hall, with clusters of lights. The wiring will all be covered by moldings, with the usual safety plugs to prevent overheating in case of excessive resistance.

The advantages of the electric light over gas for such service as the college library are very obvious. The light is much better for the eye than gas, and better illumination is secured of each area lit by one lamp. No heat incommodes the reader near a light, nor do the books or bindings receive any harm from the heat of chandeliers nor from the gases which the flames give off as products of combustion. Better ventilation and better air in the room are also secured, where the removal of noxious products of combustion is not superadded to the normal ventilation by natural means for the occupants. The steadiness of the incandescent light is what especially adapts it for such service as is required for students in a library. While the arc light would give a brilliancy of illumination more impressive for the lighting up of the void spaces in the upper part of the hall, the insurmountable flicker of the irregularly burning carbons

prohibits its introduction into rooms intended for assiduous readers. Incidental advantages of the introduction of an electric lighting plant in our college will suggest themselves to all. In the new drawing rooms of the east building, with their relatively low ceilings and mullioned windows, a cool light near the drawing desks will be of great advantage. In the observatory, no vibrating current of heated gas need seek an outlet past the object glasses out through the roof. The reticule can be illuminated as never before, and no error of side-warping from heat need be compensated for. The observer can have portable illumination for his record book without the inconveniences of gas or oil. In small projection lanterns for small screens in section rooms, the incandescent candle could be made of service. In larger rooms where the oxy-hydrogen lamp will still be used for projection purposes, a switch at the lecture-table could be made to light the darkened room, that the class might take down their notes upon the picture just projected on the screen. Darkness for the next projection could be at once secured, and the drawback of the darkened room, which precludes taking of notes, can be removed without the slower and more laborious dropping of the window screens between each slide. Many other suggestions will at once present themselves to any one reflecting upon the matter.

Should this matter of electric lighting be duly carried out, Columbia will have the claim to be the first to light its library by the new and better plan. F. R. H.

Fellowships in Chemistry.

On May 25, 1882, Dr. Chandler addressed to President Barnard a communication with regard to the appointment of Fellows in Chemistry, said Fellows to replace the assistants then holding positions.

In this letter, reference having been made to the system of assistantships then existing, and the disadvantages arising therefrom commented upon, Professor Chandler proceeded to advocate the appointment of "Fellows in Chemistry," whose duties would include the holding of recitations with the students on that subject, so as to secure for the latter a thorough drill on the matter considered in the chemical lectures.

The compensation for such services to be in case of each Fellow the the sum of $500.00 a year, and the appointment to be made for the term of one year, leaving it, however, at the option of the President and the head of the department to continue the Fellowships for a second year in special cases where a Fellow had proved particularly useful and active.

In a "Report of the Committee on the School of Mines, with Accompanying Resolutions," presented to the Trustees of Columbia College, January 3, 1883, the appointment of four Fellows is recommended, and the following resolutions appended.

Resolved, That the office of assistant in quantitative analysis, qualitative analysis, and assaying be abolished—this resolution to take effect at the close of the present financial year.

Resolved, That there be established in the School of Mines four Fellowships in Chemistry, of the value of five hundred dollars per annum, to be filled by the Board of Trustees on nomination by the Professor of Chemistry, approved by the President, and to be held for the term of one year from the date of appointment.

Resolved, That the duty of the Fellows to be appointed under

authority of the foregoing resolution shall be to render such assistance in the several laboratories as has been heretofore required of the assistants in Chemistry; and, in addition to this, to conduct recitations of the classes in Chemistry as frequently as may be practicable; each one of the said Fellows to be liable to be assigned to either duty as the exigencies of the course may require.

In virtue of the foregoing, there were appointed as Fellows, Messrs. Beebe, Bowen, Vulté and Wiechmann. The three former were assigned to the Assay, the Quantitative and the Qualitative Laboratory, respectively, the last to instruct in Chemical Philosophy, in addition to the recitations in Chemistry conducted by each.

The classes are divided into sections of about twenty each, for purpose of such recitations, in this manner insuring a thorough study and review of the ground covered in the lectures on chemistry.

F. G. W.

THE NEW LIBRARY REGULATIONS.

WITH the consolidation of the various libraries into one university collection, an entirely new code of rules has been adopted.

An exact copy of the rules and brief notes, as printed for the use of readers, is given later, and a hand-book for readers is in preparation which will give fuller information, with lists of the best reference books on various topics, and similar guides to the best use of the library.

The new rules aim at the greatest possible liberality consistent with the safety of the books and the rights of the college in general, as against individual readers.

No rule is made to enable librarians or assistants to save themselves labor, take holidays or vacations, or in any way to favor themselves. The greatest possible convenience to all users of the library is the spirit of all the rules, and any that appear at first reading to be otherwise will be found on investigation to be necessary to protect general interests.

A few seriatim notes will make this clearer.

The rules intentionally leave no option with any individual as to observance. Any rule that all, from the President and Trustees to the youngest freshman, were not to observe literally, was omitted. The Library Committee of seven trustees, who made the rules, and the librarians who enforce them, subject themselves to the same fines and penalties that they impose on others.

Instead of three hours daily for about 165 days each year, or 500 hours yearly, the reading-room and library are now to be open 14 hours daily for 312 days each year, or 4,368 hours yearly, that is over eight times as much as before. The library believes that readers should have access to the books when they want them, and not merely at stated seasons.

While the new arrangement makes the collection a reference library open much more than other purely reference libraries, yet for the accommodation of those who prefer to use the books in their private rooms, three volumes may be borrowed and kept till wanted by some other reader, if renewed each two weeks. For renewal the library only requires the numbers of the books to be given at the loan desk, without bringing the books themselves to the library.

Rule No. 8 provides for the not infrequent cases where some book is much wanted by an entire class, and has been taken out by an individual.

Privileges have been made much more liberal in giving every member of every school of the university equal rights to all the libraries. The only distinction is that for convenience in the reading-room, the tables at the left of the entrance are reserved for the schools of law and political science, the scientific schools have the centre, and the schools of arts the west end.

This brings the readers nearest the reference books and librarian of each department.

Graduates of all departments residing in New York or vicinity now have equal rights with undergraduates, without any formality of application and approval, beyond proper identification.

The purpose is to make our graduates feel as much as possible that they are still actively connected with Columbia.

For the accommodation of visitors to New York, or literary and scientific people who would specially prize our facilities in making investigations, a system of readers' tickets is provided, and any proper person known to the library or properly introduced can readily secure reading-room privileges.

The very few books which, because of their great cost or size cannot be consulted without special permit, are to be plainly marked, both on the books and in the new catalogues, so that every reader will know without asking what books he is free to use or borrow. The long sets of periodicals, transactions of societies, etc., which are liable to be wanted at any hour in the building, are included in the reference library and marked *ref.*, and can always be found in their places, unless temporarily loaned for a short time on special permit. Books given on that condition, as well as leading dictionaries and very costly works, are marked REF., in capitals, and these cannot leave the building even on written permit.

Rule No. 12 will remove the old complaint that books specially recommended for reference by the professors are at once drawn out by the student who can get to the library first, and the rest of the class are thereby deprived of their use. Every instructor may have reserved for use in the building, during the study of any topic, such special books as he selects, thus giving every member of the class equal privileges.

The confusion and the loss resulting from the carelessness of the few who take books for use in the building and then carry them off without charging, has made the stringent Rule No. 13 necessary. The heavy fines for such carelessness will not be remitted, for, as the books are charged at the very door through which every reader must leave the building, there is no excuse for forgetting. The library being for reference, and allowing books to be taken home only as a special favor, cannot allow, in any case, a second lending to some other person. This rule, and also No. 6, relieves borrowers from the annoyance of having their names filled up by others who ask to "take a book on your name." The library will not issue to any other person who does not bring a written order, and positively forbids any reader to lend a library book. If it is to be lent, the library insists on its right to make the loan directly to the person wanting the book.

The fines are practical facts, not merely ornamental attachments to the rules. There is no option left with even the chief librarian, and if a book is kept more than fourteen days, five cents per day *must be paid* by whomsoever has it, officer, student, or visitor.

Rules Nos. 19 and 20 are to protect the books from injury, as pencil tracings cut through and injure the fibre of the paper.

If ink is used, blots are now and then dropped on the books and floor, and most libraries find it necessary to forbid inkstands. A single stand, upset on the polished floor, would make a stain that could be removed only by cutting out and patching the floor, and the patch would be a disfigurement as long as the building stands. Many readers now use the various stylographic and fountain pens, that take the place of inkstands, and for other cases where it is important that ink be used, the library will provide it in a special room.

Rule No. 20 may seem needlessly stringent in forbidding corrections of the press, but it is found in practice the only safe rule. The library cannot decide the care and intelligence of various readers, and if a critical scholar is allowed to correct what he *knows* to be mistakes, the careless reader will also correct what he *thinks* to be mistakes, and will create endless confusion.

Common courtesy would prompt nearly all readers and visitors, to the strict observance of rule No. 21, but the ninety-nine thoughtful gentlemen must submit to having a rule not needed for them, because of the one-hundreth man who, without intending it, makes himself a nuisance by drumming with his fingers, or subdued humming or whispering to himself or another, or tilting and rocking in his chair, or by bringing visitors into the reading room and discussing its architecture there instead of after leaving it, or similar trifles which interfere with the rights of those who cannot study where any of these uncalled-for things are going on.

The library is glad to have visitors inspect its new quarters, but when they pass the central curtain into the quiet reading room, they must strictly observe silence. Necessary questions and comments can easily be deferred till they are again on the loan side of the curtain, where low conversation does no harm. People would be horrified at a visitor who, interested in church architecture should step in during service, and with hat on, walk heavily about and comment or ask questions audibly, and yet some do the same thing in the library where it is "during service" from 8 A.M. to 10 P.M. daily, for readers are engaged in their studies.

The attendants must check every breach of this rule, not because the noise disturbs the library staff, but because it is required to protect the rights of readers from so marked violations.

The unusually long hours of daily opening, the beautiful great reading hall with its forty large tables, abundant heat and ventilation, and floods of sunlight in every part during the day, with the almost equal electric light, now being put in, for evening work, with the rules adopted, and a staff of five librarians and fifteen assistants, all anxious to help readers in every reasonable way, combine to make the new library a matter of pride to Columbia.

1. A copy of these rules shall be given to every person using the library, and no violation of them shall be excused on the plea of ignorance.

2. The library and reading room shall be open every day from 8 A.M. to 10 P.M., except Sundays and Good Friday.

The library is not closed on legal holidays or in vacation.

3. Officers, students, and graduates of Columbia College, resident in New York city or vicinity, may borrow books from the library, which, however, are subject to recall if specially needed.

This privilege is extended to all donors to the library to the amount of one hundred dollars, and to others by the Library Committee, on written application.

4. All registered borrowers, and such others as hold a reader's ticket from the chief librarian, shall, subject to the rules, have free use of the reading room and access to the reference library.

Application for a reader's ticket should be made in person at the office adjoining the reading room.

5. None but officers shall have access to the registers, desks, inclosures, or the books, except those on the open shelves in the reading room, unless with an attendant or a written permit from the chief librarian.

The wall cases of the reading room, free of access to all readers, contain over 20,000 volumes of the most needed reference books.

6. Books shall be loaned only to registered borrowers, and delivered only on personal application, or on written order by which full responsibility for books so delivered is assumed.

7. None but officers shall keep from the library more than three volumes at a time, nor any volume longer than two weeks without renewal.

8. No reader shall keep a book more than two days after notice from the library that it is wanted.

9. No book shall be renewed if a "reserve" is on its register card.

A book wanted when out, will be reserved for the applicant two days after its return if he leave on the blank provided at the loan desk his address and the title of the book. This "reserve" will be dated and sent him immediately on the return of the book, which must be called for within two days.

10. College officers may borrow not more than twenty volumes, all subject to recall and fines, and shall return or renew all books during the first week of the October term, and the week preceding Christmas, Easter, and Commencement.

11. Books marked on the book plate and in the Catalogues "REF." are for reference *only* and are never loaned. Those marked "ref." belong to the reference library, and are loaned only on written permit. Those marked "per." can be *consulted* only on written permit.

12. The chief librarian, on request of any professor, may temporarily transfer from the loan to the reference department any books needed for constant use, or restrict the consultation of special books.

13. Any person taking from the library a book without having it "registered" shall be fined fifty cents for each offence. If a restricted book be so taken, he shall be fined one dollar.

Books issued on call-slips are for reading room use only. If to be taken from the room, they must be returned to the loan desk and "registered."

14. No book shall be lent by a borrower. [See Rule 22.]

15. Every person keeping a volume longer than the rules permit shall be fined five cents per day.

The library does not undertake to notify delinquents; therefore no claim can be allowed because notice was not received.

16. Any book, unreturned after one week's notice, may be sent for and a messenger fine of twenty cents imposed.

17. Any book, unreturned after one month's notice, may be considered lost, in which case the borrower shall pay its value in addition to the fine.

18. No reproductions by photography, tracing, etc., shall be made without a written permit from the chief librarian.

19. Readers shall not lay the paper on which they are writing or drawing on any book, manuscript, or map, nor use ink except in ink pencils or where especially provided by the library.

20. Notes, corrections of the press, or marks of any kind on books belonging to the library, are *unconditionally forbidden.* Any person violating this rule, or otherwise injuring any book, shall pay a fine satisfactory to the chief librarian, or take the book and pay all costs of replacing it.

While forced to be thus peremptory in forbidding all marks by others, the library esteems it a favor to have any needed correction or note suggested, so that the proper officer may verify and make it. It strongly urges on every reader the duty of thus assisting in correcting all errors and adding useful notes. Not only printers' and binders' mistakes, but all misstatements of facts, wrong dates, incorrect quotations or references, etc., should be reported orally, or, preferably, in writing.

The borrower is responsible for injuries by others to any book while charged to him. In signing for it at the loan desk, he agrees to *make good all injuries* (reasonable wear alone excepted), whether done personally or by lending, carelessness, or exposure.

Borrowers finding a book marked, mutilated, or defaced, should report it without delay at the loan desk. The library, assuming all books to be in proper condition when issued, must hold the borrower responsible if a book be found marked or mutilated on its return.

21. Silence and decorum shall be strictly observed in the reading room.

The use of tobacco, carrying lighted cigars, wearing the hat, sitting on tables, putting the feet in chairs or window seats, conversation even in whispers, or any act that might annoy other readers, is a breach of the strict decorum imposed by this rule.

Whispering specially annoys many readers. For any conversation whatever beyond mere necessary questions asked of librarians in the lowest audible tones, all readers or visitors *must retire* to the loan room side of the central curtain, where seats are provided and talking in low tones does not violate the rights of others.

22. For wilful violation of any library rule the chief librarian may suspend the offender from all use of the library till the case is acted on by the committee.

23. No person, except the president and members of the library staff appointed by the chief librarian, shall have a key to the library. And no key shall be lent for any purpose whatever.

24. No suspension of any rule or remission of any fine shall be made except by the Library Committee on written application; and library privileges shall be withheld from all persons whose fines are unpaid.

Fines must be paid when imposed. If afterward remitted, the money will be refunded. No student can be graduated, or honorably discharged from the college, with any unsettled accounts at the library.

By order of the Library Committee,

MELVIL DEWEY,
Chief Librarian.

Nov. 10, 1883.

ADDITIONS TO THE SCHOOL OF MINES LIBRARY SINCE OCT. 1, 1882.

American Pharmacist. 1882. Published every Saturday.
Althaus, Karl Ludwig. Ein Beitrag zur Geschicte der rheinisch-westfälischen Eisenindustrie. 8vo, 25 pp. Düsseldorf, 1882.
Annales des Sciences Géologiques. 1882, et seq.
Annals of the General Society of the Mechanics and Tradesmen of the City of New York, 4to, 420 pp. New York, 1882.
Abney, W. de Wirelesle. ATreatise on Photography. 8vo, 326 pp. London, 1881.
Bolton, Dr. H. C. Chemical Literature. 8vo, 29 pp. Salem, 1882. Donation Prof. Bolton.
Bergbangeltenden Verordnungen. Zusammanstellung der in Oberbergamtsbezirke Breslau in Bezug auf. 8vo, 68 pp. Breslau, 1882.
Blake, Wm. P. Description of the Silver King Mine of Arizona. 8vo, 48 pp. New York. 1883. Donation.
Bolton, Dr. H. C. Application of Organic Acids to the Examination of Minerals. 8vo, 7 pp. Salem, 1883. Donation Prof. Bolton.
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Webster, Noah. Unabridged English Dictionary. 4to, 1849 pp. Springfield, 1883.

Ware, William R. Modern Perspective. 8vo, 321 pp. and 4to plates. Donation, Prof. Ware.

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OBITUARY RESOLUTION.

Whereas: It has seemed good in the eyes of an all-wise Providence, to remove from us by death, our fellow-graduates FRANK STUART HELLEBERG, of the class of 1877, and HENRY ALBERT HODGES, of the class of 1878:

Resolved: That while we bow to the will of Him who doeth all things well, we do deeply deplore the loss of these our former associates, and shall keenly miss their familiar faces from our midst.

Resolved: That in their death we have lost from our number most faithful students and friends, endeared to us by their kindly disposition and thoughtfulness for others; and the profession of Mining Engineering members who gave promise in their short careers of becoming prominent by their successful achievements, earnest purpose, and high characters.

Resolved: That we hereby tender to the relatives and friends of the deceased our hearty sympathy with them in their affliction.

Resolved: That a copy of these resolutions be sent to the families of the deceased, and that they be published in the School of Mines Quarterly.

J. B. MACKINTOSH,
C. E. MUNSELL,
Committee.

HENRY ALBERT HODGES, E.M.

THE only child of Albert C. Hodges, was born at Foxboro, Mass., on April 10th, 1853. He lived there and attended school during his boyhood and youth.

He went to Europe with his mother in 1870, spending one year at "La Châtelaine," a school near Geneva, and then at Neuilly, near Paris, where he completed his study of French. He next went to Dresden, where he studied German, and commenced Spanish; after a trip to Vienna, and all the principal cities of Italy, he entered Spain and located for five months at Valencia. Here he was very dangerously ill with a complication of troubles, all proceeding from rheumatic fever, which left him with an organic disease of the heart, from which he never recovered, and which was at last the real cause of his final trouble, Bright's disease.

After returning from abroad for one year, he entered the School of Mines in October, 1874, and was one of the 18 original '78 "Preps" (out of 70) who graduated in four years.

As a companion he was always jolly and agreeable, and was a man of whom all were fond, for he had a fund of good temper and good nature that was never exhausted.

After graduating, he spent the summer of 1878 in the New England States; returning to New York late in October, he entered the office of his uncles, William D. Andrews & Brother, Tube and Driven Wells (Green's patents), as chief clerk.

In this position he showed a marked degree of ability, and by his intelligence added largely to the successes of his employers. Here he remained for four years, when his unfortunate disease compelled him to retire from the active pursuit of his profession and seek the quiet of the country at the home of his parents, at Newton Highlands, Mass., where he died on July 4th, 1883.

GRADUATE DEPARTMENT.

ON the evening of October 16th a complimentary dinner was tendered by the American Chemical Society to Professor Dr. A. W. Hofmann, of Berlin, at the Hotel Brunswick. It was pronounced by all participants—among them a number of professors and graduates of the School of Mines—a complete success.

Professor J. C. Booth, of the United States Mint at Philadelphia, presided. In a few very pleasant remarks he introduced Professor Hofmann, who responded as follows:

GENTLEMEN:

I hope you will not consider it a figure of speech if I say that I feel utterly unable to find adequate expressions for conveying my heartfelt gratitude to you for the cordial welcome offered to me on the hospitable soil of this great country; to you, friends and fellow-workers in science, for the kind manner—kind is a poor word, let me rather say in the enthusiastic way, in which you have identified yourselves with the sentiments of your chairman. I need not tell you, gentlemen, how highly I appreciate the distinguished honor you have conferred upon me by inviting me to this magnificent entertainment, affording me a most delightful opportunity of meeting so many men eminent in the science of chemistry and its varied applications, among them many whose names have been long familiar as household words in the mouths of chemists, among them old friends with whom I walked the sunny paths of youth, and one whose hand I am grasping at this moment with whom I had the good fortune of being a fellow-student in the laboratory of our cherished master Liebig, forty years ago—among them young friends, formerly pupils of mine, now holding distinguished positions in schools and universities or as directors of important chemical works or allied industries.

But, gentlemen, while fully appreciating the kind words addressed to me by our chairman, I feel in conscience bound to tell you that he has made a very colored statement. You Americans are in the habit of seeing so many big things, that I am afraid in a measure you are losing the sense of discrimination; the depth of your Niagara, the width of your Hudson, the length of your Pacific, the towering majesty of your Rocky Mountains, disturb the equilibrium of your vision. Such, at all events, has been the predicament of our chairman when he spoke of the little service to science I have done, or, I should rather say, which I have endeavored to do. Assuredly he has looked through a lens of great magnifying power, and what he has thus seen in this way he has multiplied moreover by the co-efficient of indulgence and good-fellowship, and thus a picture has ultimately been produced which I no longer recognize myself.

Be this, however, as it may, let me once more assure you how delighted I am to find myself in the company of so many chemical colleagues. My stay in this great country has been a most interesting one. I have been carried along by the mighty current of American life, of which no one can form a conception unless he has been floating on in it, but which is a very pleasant thing after the first giddiness is over. I have seen and heard so much I did not expect, that I am almost—to use a chemical term—in a state of super-saturation. At no time of my life have I felt more keenly the truth of Shakespeare's lines:

> "There are more truths in heaven and earth, Horatio,
> Than are dreamt of in our philosophies."

But I am sorry to say before this I have had little opportunity of coming in contact with chemists and chemistry; so little, indeed, that the other day I was quite happy when in Yellowstone Park one of the old geysers wafted me a sniff of sul-

phuretted hydrogen. I assure you, gentlemen, I felt like an old coachman who has been long out of service, when for the first time he hears the smack of a whip again.

I am afraid, gentlemen, I have already overtaxed your patience, but it is such a time that I have not had the pleasure of addressing a chemical audience, that you will find it reasonable, if once in possession of the word, I do not yet sit down. May I venture to claim your attention for a moment longer?

From what I have stated before, you must perceive how much the expectations with which I came to America have been surpassed. Under these circumstances you will forgive me if I frankly confess that in one respect I have met with a cruel disappointment. In Germany it is generally believed that America is the country of self-help *par excellence*. Accordingly, when crossing the Atlantic, I was delighted to think I should receive here a useful lesson in that art, for such a lesson does a man good at any time of life. In this respect, gentlemen, I have reckoned without the host. I have received no such lesson. From the moment I touched American ground, nay, before this—indeed, when the coast of this glorious country first arose from the waves, when I first beheld the outline of this noble city—the metropolis of the West, as we call her in Europe, but this name, I am afraid, would not do on this side of the water—I say from the moment of my arrival in this country American hands—kind American hands—were stretched out to me on every side, helping when help was needed, sometimes even when it was not needed. And what has happened to me on landing, I have experienced during my whole stay; whilst crossing the gigantic continent in its whole width from the Atlantic to the Pacific, whilst descending from the North down to the Gulf of Mexico, everywhere the same kindness, the same helpfulness, the same boundless hospitality. In my endeavor to learn the art of self-help I have been utterly foiled. Now, gentlemen, in a company of experimentalists, it is scarcely necessary for me to point out the only course which remains to me. We all know that if an experiment does not succeed the first time, we try again. In truth, gentlemen, I fear I must one day return to America. Perhaps I may then be more successful.

Gentlemen, according to the laws of toasting, he who replies to a toast has a right to propose a new one. Of this right I mean to avail myself. By the very logic of the circumstances, the sentiment I am going to give is fixed. Having been elected an Honorary Member of the Chemical Society of London, almost on the threshold of its creation, having been one of the founders of the German Chemical Society, and being received to-day at this glorious meeting of the American Chemical Society, I may be allowed to express the wish, the hope, the conviction, that the younger will grow and flourish like the two elder sisters. Gentlemen, three cheers for the American Chemical Society!

In response to toasts proposed by the chairman, speeches were made by Professor Horsford, of Cambridge, Professor Thurston of Stevens Institute, Professor Silliman, of Yale College, Professor Johnson of Yale College, Professor Chandler of the School of Mines, Professor Morton of Stevens Institute, Professor Vogel of Berlin, who was also a welcome guest of the Society, Professor Newberry of the School of Mines, and Professor Doremus of the New York College.

There were about ninety present, the majority of them men eminent in some special branch of science, and the meeting will always be remembered as a very enjoyable and interesting occasion.—P. N.

Bachelorhood is evidently at a discount in the Alumni Association, as is shown by the number of its younger members who have entered the bonds of matrimony within a recent period. Among these we note the names of Hudson, '80, Richmond, '81, Falk, '82, and Traphagen, '82. We may also state that the engagements are announced of Stearns, '81, Neymann, '81, and Dougherty, '82.

At a meeting of the Board of Managers of the Alumni Association, held on May 16th, 1883, President Barnard, and Professors Chandler,

Egleston, Newberry, Trowbridge, Ware, Van Amringe, Peck and Rood were unanimously elected to honorary membership in the Association.

The complete success of the second quarterly meeting of the Alumni Association, an account of which will be found elsewhere, has demonstrated beyond question the strong interest felt by the members of the Association in its welfare. It has shown, also, the great value of informal meetings such as these, in compacting and strengthening the Association, and in presenting to its members frequent opportunity of expressing their opinion with regard to matters relating to the Association, or to their Alma Mater.

It must not be forgotten, however, that in order to maintain the interest and value of these meetings, each member of the Association should endeavor to present thereat any matter of general or of professional interest upon which he may personally have worked, or which in any way may have claimed his attention. The discussion of such matter cannot fail to bring out facts of much value, and to add greatly to the benefit of those present.

It is evident, on the other hand, that without exertions such as these on the part of all members of the Association, these meetings must in time lose their value and interest; a result which it is certain every alumnus will use his best endeavors to prevent, if he can only be brought to a full realization of what he personally must do to that end.

We understand from the Treasurer of the Alumni Association that all the dues which he has so far received have been inclusive of the subscription price of the QUARTERLY. This is most gratifying evidence of the interest felt by the alumni in the QUARTERLY, and if supplemented by their intellectual support in the shape of articles and notes, will do very much towards raising the journal above even its present high plane of excellence and success.

The first quarterly meeting of the Alumni Association for the year '83–'84, was held on Wednesday evening, Nov. 7th, 1883, in Prof. Peck's room in Hamilton Hall, Columbia College.

The meeting was called to order at 8.30 P.M., by the President of the Association, F. Augustus Schermerhorn. Professors Egleston, Newberry and Trowbridge occupied seats on the platform, while the large room was comfortably filled by the Alumni, about seventy-five of whom were present.

After the reading of the minutes of the previous meeting by the Secretary, Prof. Rees, chairman of the Committee of Arrangements, stated that it was impossible to throw open the new Library and Observatory for inspection, according to announcement, as no means of lighting the former had as yet been provided. Mr. Dewey, the Librarian, had, however, promised to have everything in readiness for the next meeting, and it was probable that this might be held in the Library itself.

Reports of officers being next in order, the President stated that he had no report to make, but would take the opportunity of congratulating the Association on the large attendance, and on the interest manifested in the meetings, both of which spoke well for the future prosperity of the Association. The Treasurer made an infor-

mal report, showing a balance of $186.00 in the treasury. The Secretary reported the deaths of F. S. Helleberg, '77, at Leadville, on Oct. 4th, 1883, and Henry A. Hodges, '78, on July 4th, 1883. He also reported the election of J. K. Rees, J. B. Mackintosh and A. L. Beebe as graduate editors of the QUARTERLY, in place of E. Waller, H. S. Munroe and P. de P. Ricketts, resigned. The subjec tof making reprints from the QUARTERLY was suggested, these reprints to be published in book form. The attention of the meeting was called to changes in the constitution. The Employment Bureau was reported as doing good work. In closing his report, the Secretary referred to the annual reunion, and requested a full attendance thereat.

Reports of Committees being called for, Mr. Norris, for the Committee on Incorporation of the Association, reported progress, and stated that an act of incorporation would probably be obtained at the next meeting of the Legislature.

Prof. Egleston then addressed the meeting on the subject of the proposed division of the present School of Mines into Schools of Metallurgy, Mines, Civil Engineering, Chemistry, etc., the whole to be under the charge of a "Faculty of Applied Science." He was followed by Professors Newberry and Trowbridge, who spoke on the same subject. The remarks of these gentlemen were adverse to the proposed change, at least for the present. They were received with great interest and attention, and were greeted with hearty applause.

The President then read the following Resolutions embodying the proposed change.

COLUMBIA COLLEGE.

TITLES OF FACULTIES AND SCHOOLS.

Resolution proposed for consideration to the Committee of the Course and Statutes, October, 1883.

Resolved, That the Faculties giving instruction under the authority of the Trustees of Columbia College, be hereafter designated and known by the titles following:

1. A Faculty of Arts.
2. A Faculty of Applied Science.
3. A Faculty of Jurisprudence.

The instruction given by the Faculty of Arts shall be embraced for the present under the following departments:

A department of the English Language and Literature.
A department of the Latin Language and Literature.
A department of the Greek Language and Literature.
A department of the Modern Languages and Foreign Literature.
A department of Pure Mathematics.
A department of Applied Mathematics and Astronomy.
A department of Physics.
A department of History and Political Science.
A department of Philosophy.
A department of Political Economy.
A department of Chemistry.
A department of Geology and Palæontology.

Under the Faculty of Applied Science shall be conducted the following schools:

A School of Mines.
A School of Civil Engineering.
A School of Metallurgy.
A School of Analytical and Applied Chemistry.
A School of Geology and Palæontology.
A School of Architecture.

Under the Faculty of Jurisprudence shall be conducted:

A School of Law.
A School of Political Science.

The President and the Professors giving instruction in any School shall constitute the Board of that School, charged with such power and duties as are usually intrusted to the governing Board of a college.

The subject was further discussed by Messrs. J. K. Rees, Butler and Norris, in short addresses of much interest. Mr. Norris moved "that it be entered on the minutes that the sense of this meeting is decidedly against any change in the name of the School of Mines." This was carried unanimously. Dr. Goldschmidt then offered a motion to the effect that a committee be appointed to draw up resolutions indicative of the feeling of this Association regarding the proposed change, to obtain the vote of all the members thereon, and to acquaint the Trustees with the result of such vote. The motion was carried, and Messrs. Goldschmidt, J. K. Rees and Butler were appointed as such committee.

On motion of Dr. Ricketts, Messrs. Mackintosh and Munsell were appointed a committee to draw up suitable resolutions commemorative of the deaths of F. S. Helleberg and H. A. Hodges, said committee to report at the next meeting of the Association.

Mr. A. H. Hollick then stated that he had been requested to present the following question to be balloted on by the Association: "Should the School of Mines encourage the idea of co-education in any of the departments of Columbia College?" A motion to table having been defeated, the question was put to vote, and was decided in the negative by an overwhelming vote.

On motion, the meeting then adjourned to the supper room, where a light collation was enjoyed. The social gathering did not break up till after midnight.

The committee appointed at the Alumni meeting of Nov. 7th have issued the following circular:

SCHOOL OF MINES.

NEW YORK, NOV. 10th, 1883.

Dear Sir:

At a meeting of the Alumni Association of the School of Mines of Columbia College, held November 7th, 1883, at the School of Mines, the enclosed plan[1] for changes in the character of the School of

[1] See account of Alumni meeting preceding.

Mines, presented to the Committee on Statutes of the Board of Trustees, was considered. The sense of the meeting was decidedly opposed to the change, and the undersigned were appointed a committee to draw up resolutions to indicate the feeling of the Association, which, if approved of by the majority of the graduates, will be presented to the Trustees at their meeting upon the first Monday in December. Please sign the enclosed resolution, if it meets your approval, and return the same to Dr. S. A. Goldschmidt, Chairman, School of Mines, Columbia College, at your earliest convenience.

Yours truly,

S. A. GOLDSCHMIDT,
W. P. BUTLER, } *Committee.*

Whereas, a plan for the reorganization of the departments of Columbia College has been presented to the Board of Trustees of said college for consideration;

And whereas, The School of Mines of Columbia College has obtained a high reputation in the scientific and educational world under its present name and organization:

Now, therefore, be it Resolved, That the Alumni Association of the School of Mines would, at present, very greatly regret any reorganization of the departments of Columbia College which would in any way affect the name and status of the School of Mines, believing that the welfare of the School would be best promoted by continuing it under its present name and organization.

LOCATION OF GRADUATES.

(For exact address in each case the reader is referred to the Graduate List published in this number.)

TRAVELLING.—*In Europe:* Ayestas, '83; Párraga, '83.
BRAZIL.—Gordon, '71; Barros, '77; Jordáo, '77.
CUBA.—Brinkerhoff, '78; Francke, '80; Mesa, '82; Fiallos, '83.
CENTRAL AMERICA.—*Salvador:* Parker, '80.
ENGLAND.—*London:* Page, '82.
GERMANY.—Marsh, '79; Navarro, '80; Calman, '82; Wittmack, '82.
JAPAN.—Hasegawa, '78; Matsui, '78; Nambu, '78.
MEXICO.—*State of Chihuahua:* Holbrook, '76; Leggett, '79; Sheldon, '79. *Sonora:* Olcott, '74; Bush, '81. *State of Zacatecas:* Perry, '78.
PERU.—Pazos, '78.
ALABAMA.—Noble, '79.
ARIZONA.—*Globe:* Walker, '83. *Silver King:* Macy, '75; *Tombstone:* Church, '67; Van Blarcom, '76; Staunton, '82.
CALIFORNIA.—*Bodie:* Harker, '79. *North Bloomfield:* Radford, '77. *North San Juan:* Downing, '78. *San Francisco:* Adams, '67; Lillienthal, '70. *San Leandro:* Noyes, '75.
COLORADO.—*Aspen:* Devereaux, '78. *Colorado Springs:* Parsons, '68; Strieby, '78. *Del Norte:* Young, '82. *Denver:* Iles, '75; Leavens, '75; Ferncke, '78; Stearns, '81. *Golden:* Ihlseng, '75; Tilden, '76. *Gunnison City:* Cornwall, '76. *Idaho Springs:* Raymer, '81. *Irwin:* Reed, '77; Ridsdale, '83. *Leadville:* Bruckman, '69; Van Wagenen, '70; Booraem, '78; Cloud, '79. *Montezuma:* Lawrence, '78; Peele, '83. *Nevadaville:* Craven, '76; Cornwall, '79. *Red Cliff:* Bruen, '76. *Silverton:* Ihlseng, '77. *South Pueblo:* Emrich, '82. *Telluride:* Mathis, '79.

CONNECTICUT.—*Collinsville:* Hill '82. *Portland:* Ingersoll, '70. *Wethersfield:* Williams, '81.
DISTRICT OF COLUMBIA.—*Washington:* Hollerith, '79; Shumway, '82.
IDAHO.—*Camas:* Nichols, '77. *Galena:* McCulloh, '78; Parker, '78.
ILLINOIS.—*Aurora:* Van Arsdale, '68; Garlichs, '80; Liliendahl, '83. *Bloomington:* Tuttle, '67. *Carthage:* Ferris, '83. *Chicago:* Giddings, '67; Stockwell, '82. *Springfield:* Fitch, '82.
INDIANA.—*Terre Haute:* Colton, '73.
IOWA.—*Clinton:* Adams, '83.
KENTUCKY.—*Elizabethtown:* Reed, '79.
LOUISIANA.—*New Orleans:* Stewart, '75; Eastwick, '79.
MASSACHUSETTS.—*Boston:* Hunt, '76; Dunham, '81. *New Bedford:* Hathaway, '79. *Newburyport:* Thompson, '75. *Pittsfield:* Griswold, '81.
MICHIGAN.—*Ann Arbor:* Joy, '75. *Detroit:* Powell, '83. *Marquette:* Wetmore, '75. *Menominee County:* Cady, '77. *Negaunee:* Abeel, '83. *Opechee P. O.:* Klepetko, '80.
MISSOURI.—*St. Louis:* Potter, '69; Wheeler, '80; Sands, '82.
MONTANA.—*Helena:* Nettre, '69. *Walkerville:* Bleecker, '81.
NEBRASKA.—*Omaha:* Hoyt, '76.
NEVADA.—*Winnemucca:* Van Lennep, '67.
NEW JERSEY.—*Carlaret:* Traphagen, '82. *Dover:* Canfield, '73. *Jersey City:* Robertson, '68; Downs, '82; Vondy, '82; McKenna, '83. *Newark:* Pool, '75; Starr, '79; Stone, '79. *New Brunswick:* Austen, '72. *Orange:* Lindsley, '70; Williams, '74. *Plainfield:* Bullman, '83. *Princeton:* Cornwall, '67. *Tompkins Cove:* Roberts, '71. *Weehawken:* Payne, '82.
NEW MEXICO.—*Fort Wingate:* Wilson, '81. *Georgetown:* Smalley, '80. *Shakespeare:* Judd, '81. *Silver City:* Ross, '76. *Socorro:* Schneider, '76; Furman, '81.
NEW YORK.—*Buffalo:* Karr, '78. *Catskill:* Meserole, '81. *Hamilton College:* Chester, '68. *Hoosic Falls:* Johnson (I. B.), '79. *Ithaca:* Newberry, '78. *Lyons:* Starr, '81. *Mechanicsville:* Douglas, '81. *Orange Co.:* Parrott, '70. *Potsdam:* Heath, '67. *Poughkeepsie:* Tower, '83. *Riverdale:* Randolph, '83. *Staten Island:* Wheeler, '68; Hollick, '79. *Spuyten Duyvil:* Johnson (E. M.), '78; Johnson (G. H.), '78. *Tilly Foster:* Engel, '80. *Yonkers:* Brereton, '83.
NEW YORK CITY AND BROOKLYN.—
'67—Bridgham, Brown, Brownson, Gracie, Hale, Harmer.
'68—Barnard, Baxter, Carson, Coursen, Geer, Pistor, Platt, Schermerhorn, Smith (L.), Smith (W. A.), Stallknecht.
'69—Hooker, Jenney, Munroe, Randolph.
'70—Haight, Waller.
'71—Fales, Goldschmidt, Ricketts, Riggs.
'72—McDowell, Sloane, Wendt.
'73—Mott, Webb, Williams.
'74—Allen, Benedict, Cameron, Murray, Rees.
'75—Jackson, Pfister, Rees, Rolker, Russell, Tucker, Wells.
'76—Garrison, Gratacap, Hall, Hamilton, Hutton, King, Love, Maghee, Morewood, O'Grady, Randolph, Wallbridge, Wardlaw.
'77—Beard, Behr, Buckley, Canfield, Caldwell, Colby, Constant, Cornell, Floyd, Hildreth, Mackintosh, Murphy, Norris, Rogers, Sage, Smeaton, Smythe, Van Boskerck, Waterbury, Thacher.
'78—Benjamin, Butler, Cushman, Davis, Drummond, Elliott, Haas, Holden, Morewood, Morris, Munsell, Murphy, Noyes, Owen, Palmer.
'79—Britton, DeLuze, Haffen, Johnston, Koch, Mayer, Neftel, Nesmith, Rutherfurd, Suydam, Williams.
'80—Beebe, Benjamin, Brugman, Butler, Churchill, Clark, Elliott, Greene, Greenleaf, Hallock, Hendricks, Hooper, Hopke, Hudson, Kunhardt, Mattison, Merritt, Parks, Robinson, Ruttmann, Torrey, Walker.
'81—Andresen, Braschi, Elliott, Hemmer, Leary, Ledoux, Little, Neymann, O'Connor (M. J.), O'Connor (T. D.), Pitkin, Sawyer, Share, Roberts, Richmond, Tuttle, Van Sinderen, Vulté, Wiechmann, Williams.
'82—Conant, Cooper, Crocker, Dougherty, Downes, Feuchtwanger, Illig, Jouet, Moses, Oothout, Powers, Toucey, Wainwright, Wanier, Ward, White.
'83—Balch, Banks, Bardwell, Carrére, Channing, Endicott, Ferrer, Haasis, Humbert, Macteague, Renault, Rich, Richardson, Suter, Weed.

NORTH CAROLINA.—*Charlotte:* Hanna, '68.
OHIO.—*Briar Hill:* Meissner, '80. *Cleveland:* Foote, '75; Swain, '81. *Columbus:* Lord, '76. *Glendale:* Going, '82; Porter, '82. *Oberlin:* Wright, '75. Munroe, '79.
PENNSYLVANIA.—*Bethlehem:* Colby, '81. *Bradford:* Parsons, '82. *McKeesport:* Tonnélé, '80. *Orbisonia:* Bolton, '79. *Philadelphia:* Lillie, '74. *Pittsburg:* Robertson, '71; Singer (G. H.), '80; Singer (G. Jr.), '80; Painter, '83. *Riddlesburg:* Kelly, '77. *Scranton:* Moffatt, '68. *Shamokin:* Ludlow, '79. *West Middlesex:* Aschmann, '81.
RHODE ISLAND.—*Newport:* Putnam, '75; Willis, '78.
SOUTH CAROLINA.—*Charleston:* Chazal, '81.
TENNESSEE.—*Knoxville:* Merwin, '79. *Nashville:* Campbell, '69.
TEXAS.—*San Antonio:* Hollis, '78.
UTAH.—*Park City:* Rhodes, '79; Wilson, '82. *Salt Lake City:* Knapp, '70; Terhune, '70; Rhodes, '74; Austin, '76.
VIRGINIA.—*Backbone:* Lyman, '78.
WISCONSIN.—*Madison:* Irving, '69.
WYOMING.—*Rawlins:* Blydenburgh, '78.

LIST OF GRADUATES.

1867.

John Magnus Adams, A.B., A.M., E.M., Mining and Mechanical Engineer, Agent for Frue Vanner, etc., 109 California Street, Room 7, San Francisco, Cal.

Samuel Willard Bridgham, E.M., 49 West Twenty-third Street, New York City.

Francis Gordon Brown, E.M., Merchant, 116 East Twenty-seventh Street, New York City.

Edward Steele Bronson, A.B., A.M., E.M., Prospect Park, Brooklyn. Residence, 144 Hicks Street, Brooklyn, N. Y.

John Adams Church, E.M., Ph.D., Superintendent Tombstone Mill and Mining Co., Tombstone, Arizona.

Henry Bedinger Cornwall, A.B., A.M., E.M., Professor of Analytical Chemistry and Mineralogy, College of New Jersey, Princeton, N. J.

Edward Everett Giddings, E.M., Merchant, 21 Metropolitan Block, Chicago, Ill.

Charles King Gracie, A.M., E.M., 71 Broadway, New York City.

Albert Ward Hale, A.B., A.M., E.M., Civil and Mining Engineer, 71 Broadway, New York City.

Thomas Hayes Harmer, A.B., A.M., E.M., 113 East Thirty-seventh Street, New York City.

Frederic Milton Heath (formerly Petit), E.M., Potsdam, Saint Lawrence County, N. Y.

William Wey Tuttle, E.M., Horticulturist, care of Baird & Tuttle, Bloomington, Ill.

David Van Lennep, E.M., County Surveyor and Assayer, Winnemucca, Humboldt County, Nevada.

1868.

Augustus Porter Barnard, E.M. Address care of D. Van Nostrand, 23 Murray Street, New York City.

George Strong Baxter, A.B., E.M., Mining and Civil Engineer, Cashier North Pacific Railroad, 23 Fifth Avenue, New York City.

James Pettigrew Carson, E.M., Mining Engineer. Address, 71 Broadway, New York City.

Albert Huntington Chester, A.M., E.M., Ph.D., Childs Professor of Agricultural Chemistry, Hamilton College, Clinton, Oneida County, N. Y.

George Hampton Coursen, E.M., C.E., 307 Greenwich Street, New York City.

George Jarvis Geer, Jr., E.M., Merchant, 453 Broome Street, New York City.

George Byron Hanna, A.B., E.M., Melter, U. S. Assay Office, Charlotte, N. C.

*Archibald MacMartin, A.B., A.M., E.M., Editor and Metallurgist, 168 Fifth Avenue, New York City. Died in New York City, May 7, 1881.

Edward Stuart Moffatt, A.B., A.M., E.M., Assistant General Manager, Lackawanna Iron and Coal Company, Scranton, Pa.

George Howland Parsons, E.M., Superintendent of Land Improvement Company, Colorado Springs, Col.
William Pistor, E.M., Hamilton & Pistor, Architects, 35 Broad Street, N. Y Residence, 136 East Thirty-seventh Street, New York City.
Charles Slason Platt, E.M., Assayer, 4 Liberty Place, New York City.
Kenneth Robertson, E.M., Pequest Iron Works, Oxford, N. J.
Albert P. Schack, E.M., Ministry. Address unknown.
Frederick Augustus Schermerhorn, E.M., Trustee of Columbia College. Address, 61 University Place, New York City.
Lenox Smith, A.B., E.M., Steel Rails, 46 Pine Street, New York City.
William Allen Smith, E.M., Secretary Iron and Metal Exchange Company (Limited). Address, 16 Exchange Place, New York City.
Frederick Stallknecht, E.M., Editor 133 West Thirteenth Street, New York City.
William Henry Van Arsdale, A.B., A.M., E.M., Vice-President Aurora Smelting and Refining Company, Aurora, Ill.
Moses Dillon Wheeler, A.B., E.M., P. O. Box 231, Stapleton, Richmond County, Staten Island, N. Y.

1869.

* Thomas Monahan Blossom, A.B., A.M., E.M. Died, October; 1876, in California.
Frederick Bruckman, E.M., 125 East Eighth Street, Leadville, Col.
Alonzo Clarence Campbell, E.M. Chemist and Mining Engineer, 227 Shelby Avenue, Nashville, Tenn.
William Augustus Hooker, A.B., A.M., E.M., Consulting Geologist and Mining Engineer ; office, 2 Wall Street, New York City.
Roland Duer Irving, A.M., E.M., Ph.D., Professor of Geology and Mineralogy in the University of Wisconsin, Madison, Wisconsin, and United States Geologist in charge of survey of crystalline rocks of the Northwestern States.
Walter Proctor Jenney, E.M., Ph.D., Consulting Engineer and Geologist. Address, care of S. Jenney & Son, 128 Pearl Street, New York City.
Henry Smith Munroe, E.M., Ph.D., Adjunct Professor in Surveying and Practical Mining, School of Mines, Columbia College, New York City.
Lionel Robert Nettre, E.M., Superintendent of the Gregory Consolidated Mining Company, Helena, Lewis and Clarke County, Mont.
* Henry Newton, A.B., E.M., Ph.D. Died August 5, 1877, at Deadwood City, Dak. Ter., while occupied as Assistant Geologist of Black Hills Expedition.
William Bleecker Potter, A.B., A.M., E.M., Professor of Mining and Metallurgy, Washington University, St. Louis, Mo.
John Cooper F. Randolph, A.B., A.M., E.M., Consulting Engineer, 35 Broadway, New York City.

1870.

Ogden Haight, E.M., Stock Broker, 38 Broadway, New York City.
William Halsey Ingersoll, A.B., A.M., LL.B., E.M., United States Stamping Company, Portland, Conn.
John Augustus Knapp, A.B., A.M., E.M., General Manager Mingo Furnace, P. O. Box 515, Salt Lake City, Utah.
John Leo Lilienthal, E.M., P. O. Box 1058, San Francisco, Cal.
Stuart Lindsley, E.M., Orange, N. J.
Edward Moore Parrot, E.M., Parrott Iron Company. P. O. Address, Greenwood Iron Works, Orange Co., N. Y.
Richard Henry Terhune, E.M., Superintendent of the Morgan Silver Smelting Company, Salt Lake, Utah.
Theodore Francis Van Wagenen, E.M., General Manager Twin Lakes Consolidated Gold Placer Mining Company, Leadville, Col.
Elwyn Waller, A.B., A.M., E.M., Ph.D., Instructor in Analytical Chemistry, School of Mines, Columbia College, and Chemist to the New York Board of Health, New York City.

1871.

William E. S. Fales, E.M., LL.B., Counsellor-at-Law, 189 Montague Street, Brooklyn, N. Y.
Samuel Anthony Goldschmidt, A.B., E.M., Ph.D., Manufacturing Chemist, Columbia Chemical Works, 66 Water Street, Brooklyn, N. Y.

John Gordon, Jr., E.M. Address, care E. Johnson & Co., Rio Janeiro, Brazil.
Pierre de Peyster Ricketts, E.M., Ph.D., Instructor in Assaying, School of Mines, Columbia College, New York City.
George Washington Riggs, Ph.B., 12 West Twenty-second Street, New York City.
Gracie Sayre Roberts, E.M., C.E., New York, N. Y., Ont. & Western Railroad, Tompkins Cove, Rockland County, N. Y. Address, 88 Union Avenue, Brooklyn, E. D., N. Y.
Richard Spotswood Robertson, Jr., E.M., with Carnegie Bros. & Co., Pittsburgh, Pa.

1872.

Peter Townsend Austen, Ph.D., F.C.S., Professor of General and Applied Chemistry, Rutgers College, New Brunswick, N. J.
* Frank B. Jenney, E.M. Died in Trinidad, 1876, while engaged as Superintendent of the Orinoco Exploring Company.
Frederick H. McDowell, E.M., Beckett & McDowell, 120 Liberty Street, New York City.
Thomas O'Connor Sloane, A.B., A.M., E.M., Ph.D., Chemist, 119 Pearl Street, New York City.
Arthur F. Wendt, E.M., C.E., Consulting Engineer, 10 Cedar Street ; residence, 414 East Fifty-first Street, New York City.

1873.

Frederick A. Canfield, A.B., A.M., E.M., Consulting Engineer, Dover, N. J.
Charles Adams Colton, E.M., Professor, Rose Polytechnic Institute, Terre Haute, Indiana.
Henry Augustus Mott, Jr., E.M., Ph. D., Mining Engineer and Analytical Chemist ; 61 Broadway, Room 56, New York City.
Henry Walter Webb, E.M., Broker ; residence, 14 West Thirty-eight Street, New York City.
John Townsend Williams, E.M., Ph.B., East River Chemical Works, Forty-fourth Street and East River, New York City.

1874.

Charles Sumner Allen, Ph.B., M.D., Practising Physician, 109 East Eighty-sixth Street, New York City.
William de Liesseline Benedict, E.M., Benedict & Cole, 61 Liberty Street, New York City.
John Gedney Mott Cameron, E.M., C.E., Assayer, Spears & Howard. Address, Fifty-fifth Street and Madison Avenue, New York City.
Samuel Morris Lillie, E.M., Chemist, Harrison, Havemeyer & Co., 101 South Front Street, Philadelphia ; residence, 307 Pine Street, Philadelphia, Pa.
George Murray, E.M. City address, 235 West Twenty-third Street, New York City.
Eben Erskine Olcott, E.M., Superintendent St. Helena Gold Mine, Delicias, Sonora, Mex. Address, 111 West Thirteenth Street, New York City.
Benjamin Franklin Rees, E.M., Merchant, 37 Ferry Street, New York City.
Francis Bell Forsyth Rhodes, E.M., Superintendent Mingo Works, near Salt Lake, Utah.
Frederick Harrison Williams, E.M. Care of W. Williams, Orange, N. J.

1875.

Magnus C. Ihlseng, E.M., C.E., Ph.D., Prof. of Engineering, State School of Mines, Golden, Col.
Malvern Wells Iles, Ph.D., Metallurgist, Grant Smelting Company, Denver, Col.
Charles Edward Jackson, C.E., Assistant Engineer, Brooklyn Elevated Railroad Company. Address, 122 East Nineteenth Street, New York City.
Douglas Arad Joy, E.M., Assistant in Chemistry, University of Michigan, Ann Arbor, Mich.
* Robert Schuyler Lamson, C.E., Major in the Egyptian Army. Died at Darbour, Upper Egypt, 1876.
Harry Wenman Leavens, E.M., Denver Ore Sampling Co., Denver, Colorado

Arthur Macy, Ph.B., C.E., Silver King Mining Co., Silver King, Pinal, Arizona. Address, 609 Lexington Avenue, New York City.
William Skaats Noyes, E.M., Oakland, Cal.
Philip Charles Pfister, E.M., Black & Pfister, 142 Maiden Lane, New York City.
Franklin Pool, E.M, Chemist, Celluloid Manufacturing Company, Newark, N. J.
Bayard Taylor Putnam, E.M., Northern Trans-continental Survey, Newport, R. I.
John Krom Rees, A.B., A.M., E.M., Adjunct Professor in Geodesy and Practical Astronomy and Director of the Observatory, Columbia College, New York City.
Charles M. Rolker, E.M., Mining Engineer, 63 Broadway, New York City. Residence, 302½ Livingston Street, Brooklyn, N. Y.
Samuel Howland Russell, E.M., 417 Fifth Avenue, New York City.
Hunter Stewart, E.M., Civil Engineer, P. O. Box 1366, New Orleans, La.
Milton Strong Thompson, Ph.B., Chemist, Chrolithion Manufacturing Co., Newburyport, Mass.
John Henry Tucker, Ph.D., Supt. Philadelphia Sugar Refinery, 225 Church Street, Phila., Pa.
James Simpson Chester Wells, Ph.D., Instructor in Analytical Chemistry, School of Mines, Columbia College, New York City.
Edwin Atwater Wetmore, E.M. Care of E. A. Wetmore & Co., Iron Merchants, Marquette, Mich.
Albert Allen Wright, A.B., A.M., Ph.B., Prof. Geology and Natural History, Oberlin College, Oberlin, O.

1876.

Thomas Septimus Austin, E.M., Supt. Germania Smelting Works, Salt Lake Utah.
Frederick Everett Bruen, E.M., C.E., Red Cliff, Col.
Francis Sanderson Craven, E.M., C.E., Supt. Gold Hill Mining Company, Nevadaville, Bald Mountain P.O., Gilpin Co., Col.
George Rockwell Cornwall, E.M., C.E., Mining Engineer, Gunnison City, Col.
Herbert Carrington Foote, C.E., Professor of Chemistry, Central High School. Address, 37 Arlington Court, Cleveland, O.
Edmund Hyatt Garrison, E.M., C.E., Asst. Treas. Central Park, N. and E.R.R.R. Co., Tenth Avenue and Fifty-third Street, New York City.
Louis Pope Gratacap, Ph.B., M.A., Curator Am. Museum of Natural History, Central Park. Address, 81 Gold Street, New York City.
Robert William Hall, E.M., American Gas, Fuel and Light Co., 139 Broadway, New York City.
Schuyler Hamilton, Jr., A.B., A.M., E.M., Hamilton & Pistor, Architects, 35 Broad Street, New York City.
Francis Newberry Holbrook, C.E., Superintendent Corralitos Mining Company, Corralitos, Chihuahua, Mex. Address, care J. P. Holbrook, 254 Broadway, New York City.
Walter Lowrie Hoyt, E.M., C.E., Chemist and Assayer, Omaha Smelting and Refining Company, Omaha, Neb.
Frederick Furneaux Hunt, E.M., C.E., 4 Pemberton Square, Boston, Mass.
Frederic Remsen Hutton, A.B, A.M., E.M., C.E., Ph.D., Adjunct Professor in Mechanical Engineering, School of Mines, Columbia College. Address, 6 W. Thirty-third Street, New York City.
Charles King, Ph.B., Railway Contractor, 68 Wall Street, New York City.
Nathaniel Wright Lord, E.M., Professor of Mining and Metallurgy, Ohio State University, Columbus, Ohio.
Edward Gurley Love, A.B., A.M., Ph.D., Tester of ill. gas, Dept. of Public Works, New York; Examiner in Chem., College of Physicians and Surgeons. Address, School of Mines, Columbia College, New York City.
John Holme Maghee, A.B., A.M., C.E., 16 East Fifty-fourth Street, New York City.
Henry Francis Morewood, E.M., Importer, 34 South Street, New York City.
James William O'Grady, E.M., C.E., Horne Street, opposite Villa Place, Morrisania, New York.
James Fitz Randolph, E.M., C.E., Supt. N. Y. and Long Branch R. R., 119 Liberty Street, New York City.
William Coleman Ross, E.M., C.E., Silver City, Grant Co., New Mex.

Albert Francis Schneider, E.M., C.E., Supt. G. Billings Smelting Works, Box 211, Socorro, New Mexico.
George Cyrus Tilden, C.E., Mining Engineer, Golden, Col.
Elbert Champlin Van Blarcom, C.E., Tombstone, Ariz.
Augustus Clark Walbridge, E.M., C.E., Builder, 120 Broadway, New York City.
James Robert Wardlaw, C.E., 39 Nassau Street, Room 31, New York City.

1877.

Louis de Souza Barros, C.E., E.M., San Paulo, Brazil.
James Thom Beard, E.M., C.E., 103 St. James' Place, Brooklyn, N. Y.
Edward Behr, C.E., Piano Manufacturer, 42 Union Square, New York City.
Charles Ramsay Buckley, A.B., A.M., E.M. Address, 66 Broadway, Room 56, New York City.
Linus Bertram Cady, E.M., C.E., in Michigan. Address, 234 West Thirty-eighth Street, New York City.
Augustus Cass Canfield, E.M., 60 West Fifty-fourth Street, New York City.
John Britton Cauldwell, C.E., 6 East Forty-ninth Street, New York City.
* Henry Gilbert Clark, E.M., C.E., late Supt. Cortez Mining and Milling Co., Aurora, Nev. Died of typhoid fever, August 2, 1881.
Charles Edwards Colby, E.M., C.E., Private Assistant to Professor C. F. Chandler. Schools of Mines, Columbia College, New York City.
Charles Louis Constant, E.M., C.E., T. J. Hojer & Co., Paints, 936 Third Avenue, New York City.
George Birdsall Cornell, E.M., C.E., Civil Engineer, Asst. Eng., Bridge Dept., N. Y. W. S. & B. R. R., Mills Building. Residence, 46 West Forty-eighth Street, New York City.
Frederick William Floyd, E.M., C.E., Oregon Iron Works, 539 West Twentieth Street, New York City.
* Frank Stuart Helleberg, C.E., late Assayer and Chemist, Cummings & Finn Smelting Works, Leadville, Col. Died, Oct. 4, 1883.
Walter Edwards Hildreth, E.M., C.E., Consulting Engineer, 52 Broadway, New York City.
Axel Olaf Ihlseng, B.S., E.M., C.E., U.S. Deputy Mineral Surveyor, Silverton, Colorado.
Jose Nabor Pacheco Jordao, C.E., E.M., Ph.B., Paulista Railroad, San Paulo, Brazil.
William Kelly, A B., E.M., Superintendent Kemble Coal and Iron Co., Riddlesburg, Bedford County, Penn.
James Buckton Mackintosh, E.M., C.E., Private Assistant to Dr. Egleston, School of Mines, Columbia College, New York City.
John Glenvil Murphy, E.M., C.E., 409 Lexington Avenue, New York City.
Ralph Nichols, E.M., C.E., Viola Mining and Smelting Co., Camas, Lava P. O., Idaho.
Dudley Hiram Norris, E.M., Lawyer, 35 Wall Street, New York City. Residence, 112 Lafayette Avenue, Brooklyn, N. Y.
* James Robert Priest, E.M., C.E., late School Teacher and Surveyor, Greenville, Sinon County, Liberia, Africa. Died, 1880.
William Helsham Radford, E.M., North Bloomfield, Nevada Co., Cal.
Sylvanus Albert Reed, A.B., E.M., Rose and Reed Milling Co., Irwin, Gunnison County, Col.
Charles Louis Rogers, E.M., C.E., 39 Broadway, New York City.
Edward Eugene Sage, C.E., Assistant Assayer, United States Assay Office, New York City.
William Henry Smeaton, C.E., E.M., Mt. Vernon, Westchester Co., N. Y.
Roland Mulville Smythe, E.M., C.E., 539 Henry Street, Brooklyn, N. Y.
Arthur Thacher, E.M., C.E., 61 Broadway, (Room 25), New York City.
Robert Ward Van Boskerck, C.E., Artist, studio, 337 Fourth Avenue, New York City.
Cornelius Read Waterbury, C.E., Engineer and Surveyor. Care of Leonard & Company, 150 Broadway, New York City.

1878.

William James Adams, A.B., A.M., E.M. Address, 709 California Street, San Francisco, Cal.

Marcus Benjamin, Ph. B., 132 Nassau Street, Room 20; residence, 43 East Sixty-seventh Street, New York City.
Charles Edward Blydenburgh, A.B., A.M., E.M., Mining Expert and Prospector, Rawlins, Wyo. Ter.
Robert Elmer Booraem, E.M., Asst. Supt. Evening Star Mining Co., Leadville, Colorado.
George Charles Brinckerhoff, E.M. Address, Apartado 183, Matanzas, Cuba.
Willard Parker Butler, E.M., Counsellor at Law, 32 Park Place, New York City.
Alexander Ramsy Cushman, Ph.D., 128 East Sixteenth Street, New York City.
John Woodbridge Davis, C.E., Ph.D., Principal, School of Mines Preparatory School, 104 West Forty-second Street, New York City.
Walter B. Devereux, A.B., A.M., E.M., Supt. Aspen Smelting Co., Aspen, Colorado. Address, 219 West Eleventh Street, New York City.
Isaac Wyman Drummond, E.M., Ph.D., Chemist, F. W. Devoe & Co., 436 West Twenty-second Street, New York City.
Orrien Pinkerton Downing, Ph.B., San Leandro, Cal.
Walter Graeme Elliot, E.M., C.E., Ph.D., Elliot & Hooper, Consulting Sanitary Engineers, 252 Broadway. Residence, 250 West Forty-second Street, New York City.
Anton Fernekes, E M. Care Colorado Boot and Shoe Manu. Co., Box 1884, Denver, Colorado.
Harry Leopold Haas, Ph.B., Zucker & Levett Chemical Co., 540 West Sixteenth Street, New York City.
Yothinosuke Hasegawa, E.M., Ph.D., Engineer, Yashioka Copper Mine, Bitchu, Japan. Address, University of Tokio, Tokio, Japan.
* Henry Albert Hodges, E.M., Late Chief Clerk, Wm. D. Andrews & Bros., Drive Wells, 23 Broadway, New York City. Died July 4th, 1883.
Edward Henry Holden, C.E., Surveyor and Civil Engineer, One Hundred and Sixty-ninth Street and Boston Avenue, Morrisania, N. Y.
William Hollis, C.E., Mining Expert, Galveston, Harrisburg and San Antonio Railroad, San Antonio, Texas.
Elias Mattison Johnson, Ph.D., I. G. Johnson & Co., Malleable Iron, Spuyten Duyvil, N. Y.
Gilbert Henry Johnson, Ph.B., Chemist, I. G. Johnson & Co., Spuyten Duyvil, N.Y.
Corydon Powell Karr, Ph.B., 30 Wadsworth Park, Buffalo, N. Y.
Benjamin Bowden Lawrence, E.M., Superintendent and Mining Engineer, Montezuma Mining Co., Montezuma, Col. Address, 238 East Thirteenth Street. New York City.
Frank Lyman, A.M., E.M., Manager Stack Mine, Backbone, Alleghany Co., Va.
Edward Austin McCulloh, Ph.B. Address, P. O. Box 2346, New York City.
Nawokichi Matsui, Ph.D., Instructor in Qualitative Analysis, University of Tokio, Tokio, Japan.
George Barrow Morewood, E.M., Ph.D., Tea Importer, 34 South Street, New York City.
Gouverneur William Morris, E.M., Meyers, Rutherford & Co., 58 Wall Street, New York City.
Charles Edward Munsell, Ph.B., Milk Inspector, New York Health Department, 128 Worth Street, New York City. Address, Glen Cove, L. I.
Henry Morgan Murphy, E.M., Murphy & Co., 231 Broadway, New York City.
Kingo Nambu, E.M., Engineer, Takashima Coal Mine, Hizen, Japan. Address, University of Tokio, Tokio, Japan.
Spencer Baird Newberry, E.M., Ph.D., Professor of Chemistry, Agricultural Department, Cornell University, Ithaca, N. Y.
James Atkins Noyes, Ph.B., A.B. Address, 155 Remsen Street, Brooklyn, N. Y.
* Owen Frederick Olmsted, C.E. Died at Albany, N. Y., November 21, 1881.
Frederick Nash Owen, E.M., Civil and Sanitary Engineer, 96 Fulton Street, New York. Residence, 19 West Fifty-sixth Street, New York City.
Cortlandt Edward Palmer, E.M., Engineer, North Brother Island Hospital. Address 25 Madison Avenue, New York City.
Richard Alexander Parker, C.E., Supt. Cornway Castle Mining and Milling Co., Galena, Alturas Co., Idaho.
Vicente Felix Pazos, E.M., 122 Calle Zavala, Lima, Peru.
Nelson Williams Perry, E.M., Pinos, State of Zacatecas, Mexico.
William Strieby, A.B., E.M. Professor of Metallurgy and Assaying, Colorado College, Colorado Springs, Col.

Bailey Willis, E.M., C.E., Assistant Geologist, North Trans-continental Survey, Newport, R. I.

1879.

Nathaniel Lord Britton, E.M., Ph.D., Assistant in Geology, School of Mines, Columbia College, New York City.

Robert Bolton, Ph.B., Rock Hill Iron and Coal Co., Orbisonia, Huntingdon Co., Pa,

Leo George Cloud, A.B., E.M., Leadville, Col.

Harry Clay Cornwell, E.M., Mining Engineer, Nevadaville, Bald Mountain P. O., Gilpin Co., Col.

Louise Phillipe De Luze, C.E., 48 Pine Street, New York City.

George Spencer Eastwick, C.E., Manager of Sugar Refinery, New Orleans, La. Address, care of Havemeyer & Eastwick, Jersey City, N. J.

Louis Francis Haffen, A.M., C.E., Brewer, One Hundred and Fifty-second Street and Cortlandt Avenue, New York City.

Charles Sumner Harker, E.M., care of Bodie Tunnel Co., Bodie, Cal.

Nathaniel Hathaway, Ph.B., Analytical Chemist, New Bedford, Mass.

Herman Hollerith, E.M., U. S. Patent Office, Washington, D. C.

Charles Arthur Hollick, Ph.B., box 105, New Brighton, S. I.

Isaac Bradley Johnson, E.M., Chemist, Hoosick Malleable Iron Works, Hoosick Falls, N. Y.

Robert Andrew Johnson, C.E., Assistant Sanitary Engineer, New York Board of Health. Address, Scarsdale, N. Y.

Edward Cabot Koch, E.M., 160 East Fifty-sixth Street, New York City.

Thomas Haight Leggett, Jr., E.M., Batopilas, State of Chihuahua, Mex.

Edwin Ludlow, E.M., Mineral R. R. & Mining Co., Shamokin, Pa.

Charles Wells Marsh, Ph.B., Student, Professor Hofmann's Laboratory, Berlin, Germany.

Theophilus Smith Mathis, E.M., Telluride, Ouray Co., Col.

Ralph Edward Mayer, C.E., Assistant in Drawing, School of Mines, Columbia College, New York City.

Hubert John Merwin, E.M., Engineer, East Tennesee Iron & Coal Co., Knoxville, Tenn.

George Fanshaw Milliken, E.M., 120 Broadway, Room 27, New York City.

Otis Mortimer Monroe, Ph.B. Care of Carnegie Bros. & Co., Pittsburgh, Pa.

Knight Neftel, C.E., Ph.D., 32 Liberty Street, New York. Residence, 16 East Forty-eighth Street, New York City.

James Nesmith, E.M., 256 Henry Street, Brooklyn, N. Y.

Charles Milton Noble, E.M., General Foreman Woodstock Iron Works, Anniston, Ala.

Robert Dunn Rhodes, E.M., Ontario Mine, Park City (Parley's Park, Utah).

William Bell Stephen Reed, E.M., E. & B. S. R. R., Elizabethtown, Hardin County, Ky.

Francis Morris Rutherfurd, E.M. Care W. Rutherfurd, 244 East Thirteenth Street, New York City.

Gardner Hutchinson Sheldon, E.M., Corralitos, Chihuahua, Mex.

George Cameron Stone, Ph.B., Chemist, New Jersey Zinc and Iron Co., Newark, N. J. Address, 127 Madison Avenue, New York City.

Henry Fowler Starr, Ph.B., Chemist, Newark Steel Works. Address, 91 Mount Pleasant Avenue, Newark, N. J.

* Francis Baretto Stewart, Ph.B. Died of typhoid fever, at Harlem, New York, August, 1879.

John Richard Suydam, Jr., E.M., 43 East Twenty-second Street, New York City.

Granville Whittlesey Williams, 388 Clinton Street, Brooklyn, N. Y.

1880.

Alfred Lockwood Beebe, Ph.B., Fellow in Chemistry, in charge of Assay Laboratory, School of Mines, Columbia College. Residence, 58 East Sixty-eighth Street, New York City.

Frank Parkinson Benjamin, C.E. Address, 31 West Nineteenth Street, New York City.

Frederick Denison Browning, E.M., Engineer. Chicago Sugar Refining Co., 75 Wabash Ave., Chicago, Ill. Address, care Ledoux & Ricketts, 10 Cedar Street, New York City.

William Frederic Brugmann, Ph.B., 327 East 57th Street, New York City.
Nathaniel Butler, E.M. Care Henry Russell & Co., 42 Barclay Street, New York City.
Alfred Daniel Churchill, M. S., E.M., Ph.D., Instructor in Drawing, School of Mines, Columbia College, New York City.
Edwin Perry Clark, E.M., 340 Clinton Street, Brooklyn, N. Y.
William Elliott, Ph.B., Chemist, Elliott, Hopke & Mattison, 197 Pearl Street, New York City.
Louis George Engel, E.M., Tilly Foster Iron Mine, Tilly Foster, N. Y.
Robert Otto Francke, C.E., travelling in Europe. Address, care Francke & Co., Havana, Cuba.
Herman Garlichs, E.M., Aurora Smelting and Refining Co., Aurora, Ill.
Wilkins Updike Greene, Ph. B., 38 South Portland Ave., Brooklyn, N. Y.
James Leal Greenleaf, C.E., Assistant in Engineering, School of Mines, Columbia College, New York City.
Albert Peter Hallock, Ph.D., Chemist, N. Y. Gaslight Co.; residence, 249 East Thirty-first Street, New York City.
Henry Harmon Hendricks, Ph.B., Hendricks Bros., 49 Cliff Street, New York; residence, 512 Fifth Avenue, New York City.
Louis Mosher Hooper, C.E., Elliot & Hooper, Consulting Sanitary Engineers, 252 Broadway, New York City.
Theodore M. Hopke, Ph.B., Chemist, Elliott, Hopke & Mattison, 197 Pearl Street, New York City; residence, Hastings-on-Hudson.
Edward Henry Hudson, C.E., Wholesale Coal Trade, room 49 Trinity Building, New York City.
Frank Klepetko, E.M., Mining Engineer to Osceola and Tamarack Mining Companies. Address, Opechee P. O., Houghton County, Mich.
Wheaton Bradish Kunhardt, E.M., Engineer with the Bower-Barff Rustless Iron Co. of New York. Address, care Prof. Maynard, 35 Broadway, New York City.
Joseph Godley Mattison, Ph.B., Chemist, Elliot, Hopke & Mattison, 197 Pearl Street, New York City.
Charles August Meissner, Ph.B., Chemist, Briar Hall Iron and Coal Co. Address, Box 142, Briar Hill, Mahoney Co., O.
James Haviland Merritt, Ph.B., Chemist, Bradley White Lead Co., Water Street, New York; residence, 184 Lefferts Place, Brooklyn, N. Y.
Juan Adelberto Navarro, C.E., Student, Germany. Address, care Mexican Legation, Berlin, Germany.
Andrew McClean Parker, E.M., Sonsanate, Salvador, Central America. Address, 37 William Street, New York City.
John Randolph Parks, E.M., Churchill, Ruttmann & Parks, 39 Broadway, New York City; residence, 113 Penn Street, Brooklyn, N. Y.
Henry Alvord Robinson, Ph.B., Lawyer, with Robinson & Scribner, 102 Broadway, New York; residence, 19 East Sixty-second Street, New York City.
Ferdinand Ruttmann, Jr., E.M., Churchill, Ruttmann & Parks, 39 Broadway, New York City.
George Singer, Jr., E.M. Address, care Singer, Nimmick & Co., Pittsburgh, Pa.
George Harton Singer, E.M., Singer, Nimmick & Co., Pittsburgh, Pa.
Wallace Augustus Smalley, E.M., Surveyor and Assayer, Georgetown, N. Mex.
Maxwell Smith, C.E., Engineer, N. Y., W. S. & B. R. R. Address, 762 Madison Avenue, New York City.
Theodore Tonnelé, Ph.B. McKeesport Iron Co., McKeesport, Pa. City address, 48 East Sixty-eight Street, New York City.
Charles Herbert Torrey, Ph.B. Residence, 53 West One Hundred and Twenty-eighth Street, New York City.
Joseph Walker, Jr., C.E., 289 Fifth Avenue, New York City.
Herbert Allen Wheeler, E.M., Instructor, Washington University, St. Louis, Mo.

1881.

Charles Alfred Andresen, E.M., with Pickard & Andresen, 8 Gold Street, New York City.
Frederic Theodor Aschman, Ph.B., Chemist, Wheeler Iron Company, P. O. Box 292, West Middlesex, Mercer County, Pa.

Chas. Popham Bleecker, E.M., Assayer Alice Gold and Silver Mining Co., Wallerville, Montana.

Victor Manuel Braschi, Ph.B., Resident Graduate ; candidate for degrees of C.E. and Ph.D. Address, care of Gargozas Sons, 103 Front Street, New York City.

Edward Renshaw Bush, E.M. ; with E. E. Olcott, Sonora, Mex. Address, care J. A. Bush, 54 Wall Street, New York City.

Philip Edward Chazal, A.B., E.M., Analytical Chemist, 46 Meeting Street, Charleston, S. C.

Albert Ladd Colby, Ph.B., Instructor in Quantitative Analysis, Lehigh University, South Bethlehem, Pa.

Edward Moorhouse Douglass, C,E. U. S. Geological Survey. Address, Mechanicsville, Saratoga Co., N. Y.

Edward Kellogg Dunham, Ph.B., Student in Medicine, Harvard University. Address, 98 Boylston Street, Boston.

Arthur Henry Elliott, Ph.B., Assistant in Chemistry, College Physicians and Surgeons ; also candidate for Ph.D., School of Mines. Address, School of Mines, New York City.

Howard Van Fleet Furman, E.M., Asst. Supt. Billings Smelting Works. P. O. Box 211, Socorro, New Mexico.

William Tudor Griswold, C.E., Government Survey, Pittsfield, Mass.

Frederick Adolph Hemmer, Jr., Ph.B. Address, East Morrisania, New York City.

Chas. Breck Judd, E.M., United States Deputy Surveyor, Shakespeare, N. Mex.

Daniel James Leary, C.E., E.M. Address, 138 Keap Street, Brooklyn, N. Y.

Clement Le Boutillier, Ph.B., care of Le Boutillier Bros., 31 & 33 West Twenty-third Street, New York City.

Augustus Damon Ledoux, Ph.B., with Ledoux & Ricketts, 10 Cedar Street, New York City.

Willard Parker Little, E.M., Resident Graduate, Course in Architecture. Address, 60 West Fortieth Street, New York City.

Walter Monfort Meserole, C.E , N. Y., W. S. & B. R. R., Catskill, N. Y. Address, 590 Lorimer Street, Brooklyn, N. Y.

Percy Neyman, Ph.B., Resident Graduate. Address, care E. H. Neyman, 97 Maiden Lane, New York City.

Michael Joseph O'Connor, E.M., Resident Graduate, Course in Architecture. Address, 42 West Twenty-eighth Street, New York City.

Thomas Devlin O'Connor, Ph.B., Chemist, with Ledoux & Ricketts, 10 Cedar Street, N. Y. Residence, 42 West Twenty-eighth Street, New York City.

Lucius Pitkin, A.B., Ph.B., Chemist, Laurel Hill Chemical Works, Penny Bridge, L. I.

George Sharp Raymer, A.B., E.M., Idaho Springs, Col. Address, 63 Seventh Avenue, Brooklyn, N. Y.

William Thomas Richmond, Ph.B., 68 Thomas Street, New York City.

Arthur Carr Roberts, E.M., 372 Broadway, New York City.

Chas. Pike Sawyer, Ph.B., Chemist, Whiting Manufacturing Co. Residence, 29 West Twenty-seventh Street, New York City.

William Waldemar Share, Ph.B., Tutor in Physics, Columbia College, New York City. Address, 336 Navy Street, Brooklyn, N. Y.

Chandler Dannat Starr, C.E., N. Y., W. S. & B. R. R., Lyons, N. Y.

Thomas Beale Stearns, E.M., Colorado Machinery Co., Denver, Col.

Alfred Ernest Swain, E.M. Address, 902 Prospect Street, Cleveland, Ohio.

Edgar Granger Tuttle, E.M., 92 Prospect Place, Brooklyn, N. Y.

Alvan Howard Van Sinderen, Ph.B., Lawyer, 45 William Street, New York. Residence, 178 Columbia Heights, Brooklyn, N. Y.

Herman Theodore Vulté, Ph.B., Fellow in Chemistry ; in charge of the Qualitative Laboratory, School of Mines, New York City.

Ferdinand G. Wiechmann, Ph.D., Fellow in Chemistry ; School of Mines, New York City.

William Fish Williams, C.E., E.M. Address, Wethersfield, Conn.

Herbert M. Wilson, C.E., Topographer, U. S. Geological Survey, Fort Wingate, New Mexico. Address, 26 Vesey Street, New York City.

1882.

Albert Calman, Ph.B., Student in Germany ; care of Carlsbach & Cahn, Mayence a. R., Germany.

Thomas Peters Conant, E.M., with Thomas A. Edison. Address, care of Harper Bros., New York City.

William Hamilton Cooper, Ph.B., Constructing Engineer, with Knox & Mason, 4 and 6 Pine Street, New York City.
Francis Bacon Crocker, E.M., Curtis & Crocker, 140 Nassau Street. Residence, 54 West Twenty-first Street, New York City.
Oscar Vincent Dougherty, Ph.B., with A. Dougherty, 80 Centre Street, New York. Address, 138 Columbia Heights, Brooklyn, N. Y.
Stancliff Bazen Downes, C.E., Office of Topographical Engineer, Dept. of Public Parks, Fifth Avenue and Sixty-fourth Street, New York. Address, 719 Lexington Avenue, New York City.
William Fletcher Downs, E.M., Supt. at Dixon Crucible Co., Jersey City, New Jersey.
Anton Frederick Emrich, E.M., care of A. Eilers. P. O. Box 8 South Pueblo, Col.
David Beauregard Falk, C.E. Address, care Falk, Hirsh & Co., Charleston, S. C.
Henry Feuchtwanger, Ph.B. Address, 64 East Sixty-fifth Street, New York City.
Charles Lincoln Fitch, E.M., Springfield Iron Co., Springfield, Ill.
Charles Buxton Going, Ph.B., Chemist, Cincinnati Desiccating Company, Cincinnati, Ohio. Address, Glendale, Ohio.
William Hill, C.E., with Collins Co., P. O. Box 196, Collinsville, Conn.
William Charles Illig, E.M., Park Department, New York. Address, 327 East Forty-first Street, New York City.
Cavalier Hargrave Jouet, Ph.B., Chemist, Ledoux & Ricketts, 10 Cedar Street, New York City.
Antonia Esteban Mesa, C.E., Sagua la Grande, Cuba.
Alfred Joseph Moses, E.M., Assistant in Mineralogy, School of Mines, Columbia College, New York City.
Edward Austin Oothout, E.M., Architect, 18 Broadway, New York City.
William Stevens Page, E.M., travelling in Europe. Address, 4 Trafalgar Square, London, England.
William Barclay Parsons, Jr., A.B., C.E., Erie R. R., Bradford, Pa.
Clarence Quintard Payne, E.M., N.Y., W.S. & B. R.R., Weehawken Terminus, New Jersey.
John Bonsall Porter, E.M., licensed Instructor in Metallurgy, Cincinnati University. Address, Glendale, Ohio.
Cornelius Van Vorst Powers, Ph.B. Address, 22 West Forty-eight Street, New York City.
Ferdinand Sands, Ph.B., Chemist, with Prof. Potter, Washington University, St. Louis, Mo.
Willard Adams Shumway, A.M., E.M., U. S. Geological Survey, Washington, D. C.
William Field Staunton, Jr., E.M., Tombstone Mill and Mining Co., Tombstone, Arizona.
Nathaniel Strange Stockwell, E.M., Chicago, Ill. Address, Box 550, Orange, New Jersey.
Donald Butler Toucy, E.M., Student at Columbia Law School. Address, 57 West Fifty-third Street, New York City.
Frank Weiss Traphagen, Ph.D., Chemist, Williams, Clark & Co., 109 Pearl Street, New York City; residence, Cartaret, N. J.
Rudolph Harrison Vondy, E.M., 489 Jersey Avenue, Jersey City, N. J.
John Howard Wainwright, Ph.B., Chemist, U. S. Laboratory, 402 Washington Street, New York City.
Albert George Wanier, Ph.B., care of Frederick Beck & Co., 206 West Twenty-ninth Street, New York City.
Norbert Reillieux Ward, E.M., Contracting and Mining Engineer, 62 William Street, New York City.
William Scherf White, E.M., Surveyor, 79 and 81 Cedar Street, New York City.
William Alexander Wilson, E.M., Box 153, Park City, Utah.
Charles August Wittmack, M.S., Ph.B., Student, Prof. Baeyer's Laboratory. Address, 40 Shilling St. III., München, Germany.
Edward Leavitt Young, E.M., Assistant Superintendent Little Annie Mining Co., Del Norte, Colorado.

1883.

George Howard Abeel, E.M., Iron Cliff Mining Co., Negaunee, Michigan.
Randolph Adams, E.M., Clinton, Iowa.

A. Ayestas, Ph.B. In Europe. Address, Tegucicalpa, Honduras, Cent. Amer.
Samuel Weed Balch, E.M. With Otis Bros., Elevators, 94 Liberty Street, New York City.
John Henry Banks, E.M., Chemist, with Ledoux & Ricketts, 10 Cedar Street, New York City.
Alonzo Fink Bardwell, E.M. Care of A. F. Libby, 57 White Street, New York City.
Thomas John Brereton, A.B., C.E., Pennsylvania R. R. Address, 227 Palisade Avenue, Yonkers, N. Y.
Charles Bullman, Ph.B., resident graduate. Candidate for degree of Ph.D. Address, Plainfield, New Jersey.
Joseph Maxwell Carrére, C.E., P. O. box 3273, New York City.
John Parke Channing, E.M. Care of R. H. Channing, 36 Park Place, New York City.
George Endicott, E.M., 273 West Eleventh Street, New York City.
Cárlos Ferrer Ferrer, C.E., P. O. box 1368, New York City.
Junius Colton Ferris, E.M., Carthage, Ill.
Enrique Constantino Fiallos, C.E., Tegucicalpa, Honduras, Cent. Amer.
Dunbar Ferdinand Haasis, E.M., 142 Quincy Street, Brooklyn, N. Y.
William Scott Humbert, E.M. Care of W. B. Humbert & Co., 7 Nassau Street, New York City.
Alfred Whipple Lilliendahl, E.M., Aurora Smelting and Refining Co., Aurora, Ill.
Charles Francis McKenna, Ph.B., Havemeyer Sugar Refinery, Jersey City, N. J. Residence, 216 East Nineteenth Street, New York City.
John Joseph MacTeague, E.M., 823 Lexington Avenue, New York City.
George Edward Painter, Ph.B. Care J. Painter & Sons, Pittsburgh, Pa.
Charles Frederic Párraga, C.E. In Europe. Care of D. de Castro & Co., 54 William Street, New York City.
Robert Peele, Jr., E.M., Asst. Eng. Silver King Mining and Milling Co., Montezuma, Col. Address, care of Becket & McDowell, 120 Liberty Street, New York City.
Frederick Powell, A.B., E.M. Care of J. M. Smith, Room 24, Burns Block, Detroit, Mich.
Edmund Randolph, Ph.B., Riverdale-on-Hudson, N. Y.
Georges Renault, C.E. With W. E. Worthen, Civil Engineer, 63 Bleecker Street, New York City.
Jacob Monroe Rich, E.M., resident graduate, candidate for degree of C.E. Residence, 50 West Thirty-eighth Street, New York City.
John Clarence Richardson, E.M., resident graduate, candidate for degree of C.E. Address, 247 Broadway, New York City.
Thomas Weddle Ridsdale, E.M., Ruby Camp, Irwin, Gunnison Co., Colorado.
George Augustus Suter, E.M., 272 East Houston Street, New York City.
George Attwater Tibbals, C. E., Continental Iron Works, Greenpoint, Long Island.
Albert Edward Tower, E.M., Fallkill Iron Co., Poughkeepsie, N. Y.
Arthur Lucian Walker, E.M., Assayer, Old Dominion Copper Mining Co., Globe, Arizona.
Walter Harvey Weed, E.M., Asst. Geologist U. S. Geol. Survey, American Mus. Natural History, Seventy-ninth Street and Eighth Avenue, New York City.

ENUMERATION.

Class of 1867	13	Class of 1876	26
" 1868	20	" 1877	31
" 1869	11	" 1878	40
" 1870	9	" 1879	34
" 1871	7	" 1880	36
" 1872	5	" 1881	37
" 1873	5	" 1882	37
" 1874	9	" 1883	32
" 1875	20		
Total number of graduates			372

Total number of graduates.....372

Known to be deceased.

Class of 1868.....Archibald MacMartin.
" 1869.....Thomas Monahan Blossom.
" 1869.....Henry Newton.
" 1872.....Frank B. Jenney.
" 1875.....Robert S. Lamson.
" 1877.....Henry G. Clark.
" 1877.....Frank S. Helleberg.
" 1877.....James R. Priest.
" 1878.....Owen F. Olmsted.
" 1878.....Henry A. Hodges.
" 1879.....Francis B. Stewart.
Total..... 11

Total number of graduates living..... 361

The list is corrected to Nov. 20, 1883.

P. DE P. RICKETTS,
Secretary Alumni Association.

GRADUATES.—ALPHABETICAL LIST.

ABEEL, '83
Adams, J. M., '67
Adams, R., '83
Adams, W. J., '78
Allen, '74
Andresen, '81
Aschman, '81
Austen, '72
Austin, '76
Ayestas, '83

BALCH, '83
Banks, '83
Bardwell, '83
Barnard, '68
Barros, '77
Baxter, '68
Beard, '77
Beebe, '80
Behr, '77
Benedict, '74
Benjamin, M., '78
Benjamin, F. P., '80
Bleecker, '81
*Blossom, '69
Blydenburgh, '78
Bolton, '79
Booraem, '78
Braschi, '81
Brereton, '83
Bridgham, '67
Brinckerhoff, '78
Britton, '79
Brown, '67
Browning, '80
Brownson, '67
Bruckman, '69
Bruen, '76
Brugman, '80
Buckley, '77
Bullman, '83
Bush, '81
Butler, W. P., '78
Butler, N., '80

CADY, '77
Calman, '82
Cameron, '74
Campbell, '69
Canfield, A. C., '77
Canfield, F. A., '73
Carrére, '83
Carson, '68
Cauldwell, '77
Channing, '83
Chazal, '81
Chester, '68
Church, '67
Churchill, '80
* Clark, H. G., '77
Clark, E. P., '80
Cloud, '79
Colby, C. E., '77
Colby, A. L., '81
Colton, '73
Conant, '82
Constant, '77
Cooper, '82
Cornell, '77
Cornwall, G. R., '76
Cornwall, H. B., '67
Cornwall, H. C., '79
Coursen, '68
Craven, '76
Crocker, '82
Cushman, '78

DAVIS, '78
De Luze, '79
Devereux, '78
Douglas, '81
Downes, '82
Downing, '78
Downs, '82
Drummond, '78
Dunham, '81

EASTWICK, '79
Elliot, '78
Elliott, Wm., '80
Elliott, A. H., '81
Emrich, '82
Endicott, '83
Engel, '80

FALES, '71
Falk, '82
Fernekes, '78
Ferrer, '83
Ferris, '83
Feuchtwanger, '82
Fiallos, '83
Fitch, '82
Floyd, '77
Foote, '76

* Deceased.

Francke, '80
Furman, '81

GARLICHS, 80
Garrison, '76
Geer, '68
Giddings, '67
Going, '82
Goldschmidt, '71
Gordon, '71
Gracie, '67
Gratacap, '76
Greene, '80
Greenleaf, '80
Griswold, '81

HAAS, '78
Haasis, '83
Haffen, '79
Haight, '70
Hale, '67
Hall, '76
Hallock, '80
Hamilton, '76
Hanna, '68
Harker, '79
Harmer, '67
Hasegawa, '78
Hathaway, '79
Heath, '67
*Helleberg, '77
Hemmer, '81
Hendricks, '80
Hildreth, '77
Hill, '82
*Hodges, '78
Holbrook, '76
Holden, '78
Hollerith, '79
Hollick, '79
Hollis, '78
Hooker, '69
Hooper, '80
Hopke, '80
Hoyt, '76
Hudson, '80
Humbert, '83
Hunt, '76
Hutton, '76

IHLSENG, M. C., '75
Ihlseng, A. O., '77
Iles, '75
Illig, '82
Ingersoll, '70
Irving, '69

JACKSON, '75
Jenney, W. P., '69
*Jenney, F. B., '72
Johnson, E. M., '78
Johnson, G. H., '78
Johnson, I. B., '79
Johnston, '79
Jordao, '77
Jouet, '82
Joy, '75
Judd, '81

KARR, '78
Kelley, '77
King, '76
Klepetko, '80
Knapp, '70
Koch, '79
Kunhardt, '80

*LAMSON, '75
Lawrence, '78
Leary, '81
Leavens, '75
Le Boutillier, '81
Ledoux, '81
Leggett, '79
Lilliendahl, '83
Lilienthal, '70
Lillie, '74
Lindsley, '70
Little, '81
Lord, '76
Love, '76
Ludlow, '79
Lyman, '78

MACKINTOSH, '77
*MacMartin, '68
MacTeague, '83
Macy, '75
Maghee, '76
Marsh, '79
Mathis, '79
Matsui, '78
Mattison, '80
Mayer, '79
McCulloh, '78
McDowell, '72
McKenna, '83
Meissner, '80
Merritt, '80
Merwin, '79
Mesa, '82
Meserole, '81
Milliken, '79
Moffatt, '68
Morewood, H. F., '76
Morewood, G. B., '78
Morris, '78
Moses, '82
Mott, '73
Munroe, H. S., '69
Munroe, O. M., '79
Munsell, '78
Murphy, J. G., '77
Murphy, H. M., '78
Murray, '74

NAMBU, '78
Navarro, '80
Neftel, '79
Nesmith, '79
Nettre, '69
Newberry, '78
*Newton, '69
Neymann, '81
Nichols, '77
Noble, '79
Norris, '77
Noyes, W. S., '75
Noyes, J. A., '78

O'CONNOR, M. J., '81
O'Connor, T. D., '81
O'Grady, '76
Olcott, '74
* Olmstead, '78
Oothout, '82
Owen, '78

PAGE, '82
Painter, '83
Palmer, '78
Parker, R. A., '78
Parker, A. McC., '80
Parks, '80
Parraga, '83
Parrot, '70
Parsons, G. H., '68
Parsons, W. B., '82
Payne, '82
Pazos, '78
Peele, R., Jr., '83
Perry, '78
Pfister, '75
Pistor, '68
Pitkin, '81
Platt, '68
Pool, '75
Porter, '82
Potter, '69
Powell, '83
Powers, '82
* Priest, '77
Putnam, '75

RADFORD, '77
Randolph, E., '83
Randolph, J. C. F., '69
Randolph, J. Fitz, '76
Raymer, '81
Reed, S. A., '77
Reed, W. B. S., '79
Rees, B. F., '74
Rees, J. K., '75
Renault, '83
Rhodes, F. B., '74
Rhodes, R. D., '79
Rich, '83
Richardson, '83
Richmond, '81
Ricketts, '71
Ridsdale, '83

* Deceased.

Riggs, '71
Roberts, G. S., '71
Roberts, A. C., '81
Robertson, K., '68
Robertson, R. S., '71
Robinson, '80
Rogers, '77
Rolker, '75
Ross, '76
Russell, '75
Rutherford, '79
Ruttman, '80

SAGE, '77
Sands, '82
Sawyer, '81
Schermerhorn, '68
Schneider, '76
Shack, '68
Share, '81
Sheldon, '79
Shumway, '82
Singer, G. H., '80
Singer, G., '80
Sloane, '72
Smalley, '80
Smeaton, '77
Smith, W. A., '68
Smith, L., '68
Smith, M., '80
Smythe, '77
Stallknecht, '68
Starr, C. D., '81
Starr, H. F., '79
Staunton, '82
Stearns, '81
* Stewart, F. B., '79
Stewart, H., '75
Stockwell, '82
Stone, '79
Strieby, '78
Suter, '83
Suydam, '79
Swain, '81

TERHUNE, '70
Thacher, '77
Thompson, '75
Tibbals, '83
Tilden, '76
Tonnelé, '80
Torrey, '80
Toucy, '82
Tower, '83
Traphagen, '82
Tucker, '75
Tuttle, W. W., '67
Tuttle, E. G., '81

VAN ARSDALE, '68
Van Blarcom, '76
Van Boskerck, '77
Van Lennep, '67
Van Sinderen, '81
Van Wagenen, '70
Vondy, '82
Vulté, 81

WAINWRIGHT, '82
Walbridge, '76
Walker, A. L., '83
Walker, J. Jr., '80
Waller, '70
Wanier, '82
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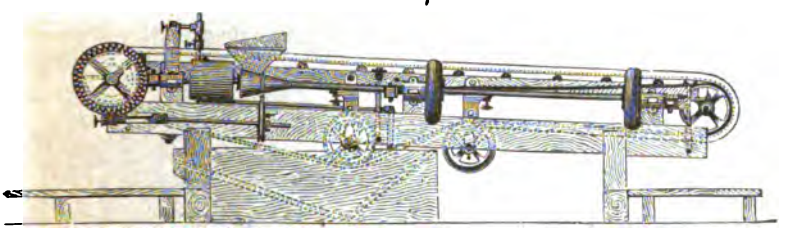

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THE METROLOGICAL SYSTEM OF THE GREAT PYRAMID.

Read before the American Metrological Society, on December 27, 1883.

BY PRESIDENT F. A. P. BARNARD, LL.D., S.T.D.

IN every stage of society, even the rudest, the interchange between individuals of articles of personal property has been going on from the earliest time. Very imperfect notions, however, were originally entertained of the relative value of the objects thus exchanged. The esteem in which they were held had been, of course, dependent upon their properties—but properties so widely different as those of practical utility and empty ornament. In the earliest transactions of the primitive races, articles of barter were probably transferred by tale, and *number* constituted the only measure of quantity. But as advancing civilization brought with it juster notions of economy, the desire of each individual to secure the largest returns for the labor of his hands, or for his diligence in the chase, led to closer scrutiny of the terms of every transaction of bargain and sale, and thus created a demand for the means of ascertaining with some approach to exactness, the amounts of merchandise transferred. In some cases the questions thus arising concerned length, in others weight, and in others bulk. In regard to length, reference was naturally made to the dimensions of some part of the human person, as being always present for verification. Hence the use of such measures as the

foot, the ell (*ulna*, the elbow, *i. e.*, the fore-arm), the cubit (*cubitus*, of similar signification), the yard (*geard*, *gyrd*, the girdle), the digit (*digitus*, finger, *i. e.*, a finger's breadth), etc., etc. For weight and bulk, such natural standards do not present themselves. It was necessary to adopt units arbitrary in their character; and as the magnitude of these units would be determined by the uses they would be required most frequently to subserve in the ordinary business of life, it has happened that, though many have originated among different peoples, independently of each other, there has been everywhere an approximation to a common mean value. Thus the unit of weight has been found, for the most part, to vary between five and ten thousand English grains troy; though in a limited number of instances it has fallen outside of these limits. Similar variations have been found in the leading units of capacity. It has only been when, in the progress of enlightenment, systems of metrology have been formed on scientific principles, that units of weight and measure have been connected with, and made dependent on, units of length. In the earlier stages of society, commercial exchanges between different countries, and even between different provinces, towns and villages of the same country, were infrequent and of comparatively insignificant importance. Each small community, therefore, originated its own system of weights and measures; and the total number of such systems simultaneously existing, has always, down to the middle of the present century, been excessively great. Some idea of this diversity may be formed from an examination of the tables presented to the Society some time since, and printed in Barnard's Metric System, published in 1879 in Boston, of the values given to a particular weight and a particular measure similarly named throughout Europe and the countries colonized by Europeans, and known as the pound weight (*pondus*, or *libra ponderis*), and the foot measure (*πούς*, pes, pé, pié, pied, fuss, fot, fod, foot), in which will be found no fewer than three hundred and ninety-one different pound weights, and two hundred and ninety-two different foot measures; all, with the exception of two or three, derived from antiquity, in actual use, somewhere or another, at the close of the eighteenth century.

It was in the hope of removing the confusion, and remedying the inconvenience to all mankind occasioned by this multiplicity of the forms of expressing the quantities of ex-

changeable commodities, that in the years preceding the outburst of revolutionary violence in France, and while the king was still on the throne, overtures were made to the British Government by King Louis XVI., at the instance of the Constituent Assembly, inviting the appointment of a joint committee of members of the Royal Society of London and of the French Academy of Sciences, to agree upon some natural standard of length as a basis of an universal system of weights and measures. This was the first step in a movement which culminated in the adoption, on the 22d of June, 1789, by an international commission called to meet at Paris, and composed of delegates of ten independent States, of the ten-millionth part of the quadrant of the Paris meridian, under the name of the metre, as the basic unit of a new and improved system of weights and measures. The system founded upon this base, and called therefore the metric system, has, in subsequent years, been generally adopted by civilized nations. Those which have hitherto failed to accept it are England, the United States, and Russia; but even in these countries, its use has become general among scientific men.

Very decisive indications make it evident that the introduction of this system for exclusive use in all these countries is only a question of time. In Russia, the use of the system in the custom houses was ordered as early as 1870. In 1876, an Imperial Commission sent to Paris to inquire into the operation of the system in Western and Central Europe, made on its return a favorable report. In the British House of Commons, in 1868, a bill making the use of the system compulsory, after a time to be fixed by the Government, passed its second reading by a heavy majority, but was not put upon its final passage, in consequence of a representation by the ministry that it would be judicious, before further action, to await the report of a commission previously appointed by the crown, to inquire into the state of the standards, and to advise as to the legislation needed in regard to them. This commission reported, in 1869, as their "unanimous conclusion," that "the best course is cautiously but steadily to introduce the metric system into this country." In 1871, a bill making the system compulsory in England after a limited term of years, was again introduced into Parliament; but a number of influences conspired to make the occasion inopportune, and it was not passed to a vote.

In our own country, the permissive use of the system was sanctioned by act of Congress in 1866. Early in 1879, a report of the Committee on Coinage, Weights and Measures, of the House of Representatives, signed unanimously, recommended the use of the system in the post-offices and custom-houses of the United States; and a bill designed to give effect to that recommendation was introduced. Unfortunately, the report was made so late as February to a Congress about to expire by limitation on the fourth of March, and time did not allow its consideration. The States of Connecticut, Massachusetts and New Jersey have, by their legislation, favored the introduction of the system, and have provided that its principles shall be taught in the public schools.

From evidences like these, it must be manifest to every thinking man that a system which has already been so widely accepted as a means of regulating the ordinary transactions of business between man and man in every-day life, and which is involved in the greater part of the international commerce of the human race, must sooner or later be universally prevalent. Some time may yet elapse before this anticipation is realized, as the absurd system of metrology now in existence among us gives token that it is not likely to die easily. In this country the opposition has even been organized, and an "Institute" has been established, calling itself "International," and professing to be designed "for preserving and perfecting weights and measures," which, during the past three or four years, has been flooding this country with its circulars, and bombarding Congress with its petitions. This agitation may not be without some temporary effect, especially in the way of scaring politicians, who are always frightened by clamor of any kind, whether accompanied by sense or not; but in its influence upon the great and steady march of public opinion, its ultimate effect will be about equal to that produced by the honest old lady who attempted to sweep back the rising tide of the Atlantic with a broom.

A favorite argument with the association above named, and of the simple-minded enthusiasts who, in this country and in Great Britain, concur in the views which it advocates, is that the weights and measures now in use among us are an *inheritance* received by us from those early generations among which God himself condescended to be the immediate ruler of his chosen people; that they were directly prescribed by Him

to Moses or the earlier patriarchs, and, therefore, that to prefer any others before them is an act not of folly merely, but of sin. This doctrine has grown out of some curious speculations as to the principles which governed the construction of the great pyramid of Cheops, at Gizeh, and the purposes for which that huge and senseless pile was constructed. It is asserted that this mysterious structure is the material embodiment of a mass of scientific truth which has hitherto been supposed to have become known to the human race only in comparatively recent times; and which was perhaps not known to the builders themselves, but was incorporated into their work through a divine guidance, which they unconsciously obeyed. And the object, it is claimed, for which the supreme ruler of the universe impelled these, his agents, to erect this massive and costly monument was merely to perpetuate to coming generations a knowledge of the weights and measures which he had himself given to his chosen people as early as the Exodus, or probably earlier. The originator—he regarded himself as the discoverer, but we should rather incline to consider him the ingenious inventor—of this singular theory, was John Taylor, of London, a man of intelligence and of some pretensions to science, who, in 1859, published a book entitled "The Great Pyramid: Why it was built, and who built it?" The second question embraced in this title is, after an elaborate inquiry, thus answered by the author: "Omitting HAM and his descendants, and leaving it doubtful whether JAPHETH, or any of his family, were engaged in this great undertaking, we have for the probable founders of the Pyramid: 1, NOAH; 2, SHEM; 3, ARPHAXAD and his brethren, *Elam*, *Ashur*, *Lud* and *Aram;* 4, SALAH and his cousins, *Uz*, *Hul*, *Gether* and *Mash;* 5, EBER; 6, PELEG and his brother, JOKTAN; 7, REU and his cousins, the THIRTEEN SONS OF JOKTAN; by some of whom, if not by all, was commenced, carried on, and completed the most magnificent, disinterested, and glorious work that was ever conceived and executed by mankind." He adds: "To NOAH we must ascribe the original idea, the presiding mind, and the benevolent purpose. He who built the ark was, of all men, the most competent to direct the building of the Great Pyramid." There seems to be something bordering on the ludicrous in the ascription to a man situated as Noah was at that time—a man just escaped from a catastrophe so frightful as the destruction of the whole

human race, his own immediate family only excepted—there is something approaching sublimity in the absurdity of ascribing to a man in circumstances so forlorn—left companionless, helpless, almost alone, to begin anew the battle of life amid the wreck of a ruined world—a project, so wild, so cyclopean, so almost stupidly idiotic, as that of heaping up a pile of massive rock a million and a half cubic yards in volume, and, according to the calculations of Professor Piazzi Smyth, more than five and a quarter millions of pyramid tons, and exceeding six and a half millions of tons, avoirdupois, of two thousand pounds each, in weight—a structure which occupied, as Herodotus informs us, a hundred thousand men no less than twenty years in building. It is a little remarkable, also, that Mr. Taylor, in the same work in which he ascribes the building of the pyramid to Noah and his descendants, and especially to Joktan and his thirteen brothers, quotes no less than five times the great work of Col. Howard Vyse, published in 1840, in which it is shown from inscriptions found in the monument itself, in the cavities called construction-chambers, discovered by him—cavities closed up by the builders and intended never to be visited—that the tradition which ascribes the construction of this stupendous monument of folly to King Khufu (otherwise Suphis or Cheops), of the fourth of the dynasties of Manetho, is correct.

The metrological theory of the pyramid has been accepted on faith by many who have not examined it themselves, but who have been carried away by the apparent ardor of conviction, and very real and fiery dogmatism, of its devotees. It has been made an article of faith by the "Institute for Preserving and Perfecting Weights and Measures," above mentioned; which Institute places at the head of its circulars the figure of the pyramid, over which is a miniature pyramid, resplendently radiant, and symbolical of the light which this structure was designed, according to the hypothesis, to shed upon the world: It is a part of the theory that the metrological system embodied in the pyramid is almost exactly identical, as to all three of the units of length, capacity and weight, with that which is at present in use among ourselves, and which, having been received from our Anglo-Saxon forefathers, has been somehow miraculously transmitted to us through them, from the time of its founders. The doctrine of the pyramid has become, therefore, something more than a

speculative hypothesis: it has become, to borrow an expression from Mr. Proctor, nothing less than "a religion." The advocates of a real improvement of the world's systems of weights and measures cannot, therefore, afford to let this singular theory pass wholly unnoticed. If the issue concerned opinions only, they might be content to let it run its course, in the assured certainty that it would, in due time, die a natural death. Its practical bearing, however, so far as the minds of men are affected by it, is pernicious, inasmuch as it seriously obstructs measures of the highest importance to the amelioration of the condition of man in society, and to the facilitation not only of commercial exchanges, but of intelligent intercourse between nations.

It is on this account that I propose, in the present paper, and in one which I hope to present to the society hereafter, to examine this theory, which may, I suppose, with propriety, be called the Theory of *the Divine Legation of the Great Pyramid.*

I shall endeavor first to state, with some attention to detail, what this theory is. I shall then inquire what are the ascertained facts alleged in its support, and shall seek finally to examine how far these facts justify the deductions which have been made from them by the preachers of the pyramid faith.

The doctrine in question then affirms, first, that the external dimensions of the pyramid have been determined by means of a unit of linear measure which is one ten-millionth part of the polar radius of the earth; and that this unit is identical in length with the cubit intended in the instructions given to Moses for the construction of the ark of the covenant and of the tabernacle and its furniture, as recorded in the twenty-fifth chapter of Exodus. It is also assumed that the twenty-fifth part of this cubit exceeds one British inch by the one-thousandth part only; that is, by a difference equal to the thickness of an ordinary spider line. It is inferred, therefore, that this is the original value of the British inch, which, during the past four thousand years, has degenerated by one one-thousandth part. Accordingly, for the sake of distinction, the twenty-fifth part of this cubit (called, from its supposed origin, the sacred cubit) is spoken of as *the pyramid inch.* It follows that the pyramid inch is one two-hundred-and-fifty-millionth part of the earth's polar radius, or one five-hundred-millionth part of the earth's polar axis.

The next proposition of this surprising creed is, that the linear measure of one side of the pyramid, at its base, contains this sacred unit of measure as many times as there are days in the year, including the fraction of a day beyond the three hundred and sixty-five; that is, that the base measure equals 25×365.2422; this last number expressing in days the length of the tropical year. There was some hesitancy for a time as to whether the sidereal year of 366.2596 days should not be taken, as measures may be found among the different authorities which will easily accommodate themselves to either; but the tropical year has been finally accepted; and it is at present orthodox to believe in it.

The third proposition is, that the height of the pyramid (in its original and perfect condition) when multiplied by the ninth power of *ten*, expresses the distance of the sun from the earth with an exactness which puts to shame all determinations from transits of Venus, oppositions of Mars, perturbations of the moon, or any other method depending on merely human science.

We are next informed that the daily motion of the earth in its orbit is expressed "in the round decimal number of 100,000,000,000 pyramid inches." It seems to be a consequence resulting from the superhuman character of the sacred orbit, that a variety of great natural dimensions measured by it are expressible in "round decimal numbers."

In order to understand the propositions which are to follow, reference must be made to a diagram showing the disposition of the passages and open spaces on the interior of the pyramid, so far as they have been discovered, with their relations to each other.

The figure shows a vertical section through the pyramid, in the plane of the axes of its interior passages. The strong line bounding the figure shows the exterior surface of the structure in its present injured condition. The fainter line without marks the finished surface, as it existed before the covering of compact and polished Mokattam limestone had been torn away. The descending entrance is marked A. The irregular passage, marked B, is the forced entrance made by the Caliph Al Mamoun, about the year 820 A.D. This does not intersect the regular passage, A, though it passes it at a distance of about twenty feet to the west and meets the ascending passage, marked D, farther on. E is a horizontal passage leading

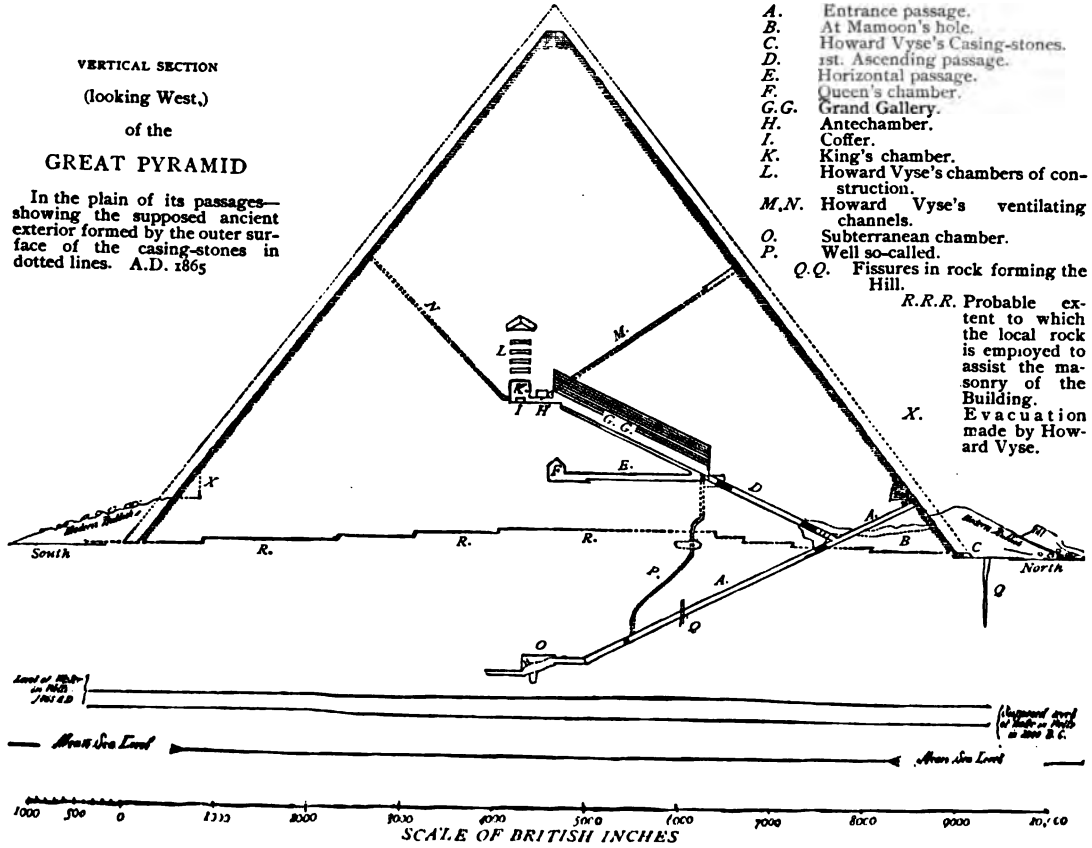
VERTICAL SECTION

(looking West,)

of the

GREAT PYRAMID

In the plain of its passages—showing the supposed ancient exterior formed by the outer surface of the casing-stones in dotted lines. A.D. 1865



A. Entrance passage.
B. At Mamoon's hole.
C. Howard Vyse's Casing-stones.
D. 1st. Ascending passage.
E. Horizontal passage.
F. Queen's chamber.
G.G. Grand Gallery.
H. Antechamber.
I. Coffer.
K. King's chamber.
L. Howard Vyse's chambers of construction.
M,N. Howard Vyse's ventilating channels.
O. Subterranean chamber.
P. Well so-called.
Q.Q. Fissures in rock forming the Hill.
R.R.R. Probable extent to which the local rock is employed to assist the masonry of the Building.
X. Evacuation made by Howard Vyse.

to F, the so-called queen's chamber. G, G is the grand gallery, H is the ante-chamber, K the king's chamber, with I, the sarcophagus, otherwise called the coffer, within it. At L are the cavities in the masonry over the king's chamber, supposed to have been left to prevent the crushing in of the ceiling of that chamber by the weight of the superincumbent mass. M and N are the passages supposed to have been intended for ventilation. O is the subterranean chamber, unfinished. P is the irregular passage called the *well*, through which the workmen are presumed to have effected their retreat, after effectually plugging up with granite blocks, the lower end of the ascending passage D, at the point where Al Mamoun's forced passage meets it. Q, Q are natural fissures in the rock on which the pyramid is founded. R, R, R are terraces cut in the rock in preparing for the building. X is a cut made in the south side of the pyramid by Col. Howard Vyse, in 1837.

This is not a place to give a description of this remarkable monument. Those who wish to inform themselves more particularly about it, are referred to the great work of Col. Howard Vyse published in London in 1840, and to Prof. Piazzi Smyth's "Life and Work at the Great Pyramid," Edinburgh, 1867. The object of the introduction of this illustration (borrowed from the work last named) is simply to make the references in the present article to the different parts of the structure spoken of, intelligible.

Referring to this diagram, we proceed with doctrine of the pyramid. In the further unfolding of this doctrine, it is next to be stated that the lengths of the principal of the passages here shown are affirmed to have been determined with reference to three of the most important events in the history of the human race, viz., the dispersion of mankind at Babel, the Exodus of the Israelites from Egypt, and the birth and crucifixion of Jesus Christ. The passages are assumed to be measures of the lapse of time, each inch of length being representative of a year. Thus, from the beginning of the descending entrance passage down to the point at which this is intersected by the passage ascending, we have the interval between the dispersion and the Exodus; from the intersection just named to the beginning of the grand gallery, we have the duration of the Jewish dispensation ending with the birth of Christ; from this point measured horizontally to the mouth of a nearly vertical but irregularly descending passage called the *well*, is

represented the duration of the life of the Saviour, the thirty-six months of his active ministry being more particularly symbolized by significant accompanying peculiarities of construction. At the point marked as representing the birth of Christ, the ascending passage, previously low and narrow, not exceeding about fifty-three inches in vertical height by forty-one and a half in breadth, suddenly expands to magnificent dimensions symbolizing the glorious freedom of the Christian dispensation, as contrasted with the previous narrowness and severity of the rule of the law. This gallery ends at its southern and highest extremity in a wall which leans northwardly by an inclination of not less than a degree. What the pyramid religionists understand by this inclination may be gathered from the following remark concerning it taken from the new and enlarged edition of the work of Prof. Piazzi Smyth, entitled "Our Inheritance in the Great Pyramid," published in 1874. "The Bible," says Prof. Smyth, "fully studied, shows that he [Christ] intended that first dispensation to last only for a time; a time, too, which may terminate much sooner than most men expect, and shown by the southern wall *impending*." As the length of the grand gallery, measured from the point marking the birth of Christ to the south inclining walls, is on one side of it 1882.6 inches in length, and on the other 1883, or in the mean, 1882.8 [Smyth's "Life and Work of the Great Pyramid," ii. pp. 76, 77], it is evident that the impending crisis, whatever it may be, is due in this present year, and that the point of time at which it was to manifest itself is already past.

The article of the pyramid faith next to be mentioned, is that the object found in the king's chamber, having the form and general appearance of a sarcophagus, and which, until the publication of John Taylor's work, had always been regarded as such, is not a sarcophagus at all, but a measure of capacity, equal to four British "*quarters*" of eight bushels each. The name *quarter* continues to be in use in England, but there is no grain measure in use there of which this is a quarter in capacity. The name is assumed to be a survival from some period of antiquity in which the recognized unit was equal in capacity to this pyramid coffer. This object, called a coffer by the pyramidists, and a sarcophagus by the scoffers, has not, it is true, in its present condition, the capacity asserted. One side of it has been cut down nearly an inch and three-quarters,

and the other three sides have been cut down on the interior to the same depth, leaving a depressed horizontal ledge evidently designed to support a lid. The inner surfaces of the cut on these three sides lean inward, or are shown by parts remaining to *have* leaned inward when perfect, so as to form a dovetail, plainly designed in this, as in other sarcophagi, to prevent the lid, when in place, from being lifted. No lid, however, has been seen by writers within the last three centuries; and it seems to be matter of doubt with true believers whether there ever was a lid. Some, apparently, incline to think that the cutting down and preparation *as if* to receive a lid, is a work of profane intruders, executed long after the completion and sealing up of the pyramid; but no doubt is entertained at all that the ruling purpose for which the coffer was constructed was to express a capacity such as *would* now belong to the vessel if restored to the form of a regular box, by replacing on every side the parts which have been cut away. There are some curious relations of number or volume said to exist between the exterior and interior dimensions of this coffer, and also between the coffer itself and the apartment in which it is situated; but these, if real, though they may illustrate a certain capricious ingenuity on the part of the designer, have nothing to do with the character of the box as a standard of capacity.

The geographical position of the monument is also an article of the pyramid faith. It stands very nearly on the thirtieth parallel of north latitude. The design of the builder was evidently to place it exactly on that parallel; but the rocky eminence on which it is founded fell off a little more than a minute of space too soon, and its actual latitude is 29° 58′ 51″. The motive inducing the choice of this latitude, according to the Pyramid religion, was that its interior temperature might correspond to the mean temperature of the entire inhabited world, which is assumed to be that belonging to the climate of 30° north latitude. Its longitude, moreover, was not matter of indifference. Its builders, according to Prof. Piazzi Smyth, were of a race not native to the country, who came into it from the East, for no other purpose but to erect this prophetic monument, and who retired from it toward the East again after their mission had been fulfilled. That their mission was divine is further inferred from the fact that they never built any architectural structure comparable to this, either in Egypt or out-

side of it, or even any other of importance at all, either before their intrusion into the Nile Valley or after they had left it. The inference is that Egypt was, by some geographical necessity, the country in which this mission had to be accomplished. The nature of this necessity, as it is regarded by the faithful, may be inferred from the following extract taken from Prof. Smyth's work above cited, "Our Inheritance in the Great Pyramid," p. 67. "Proceeding along the globe due north and south of the Great Pyramid, it has been found by a good physical geographer as well as engineer, William Petrie, that there is more earth and less sea in that meridian than in any other meridian all the world round, causing, therefore, the Great Pyramid's meridian to be just as essentially marked by nature across the world as a prime meridian for all nations measuring their longitude from, as it is more minutely marked by art and man's work for the land of Egypt alone. Again," he continues, "taking the distribution of land and sea in parallels of latitude, there is more land surface in the Great Pyramid's parallel of latitude than in any other. And, finally," he concludes, "on carefully summing up all the dry land habitable by man all the wide world over, the center of the whole falls within the Great Pyramid's territory of Lower Egypt." We are constrained, therefore, to believe it to have been a part of the divine purpose in locating the Pyramid, to make known to man the exact position of the geographical center of the habitable world. And accordingly it is not surprising that Prof. Piazzi Smyth is now a declared advocate of the adoption of the meridian of the Great Pyramid, as the prime meridian from which all the nations of the earth should reckon their longitudes.

In regard to temperature, Prof. Smyth says of the 30th parallel: "That 30° zone represents the climatic conditions of a larger part of the earth than any other possible zone; and being also the parallel which has in either hemisphere an equal amount of surface between it and the pole on one side, and between it and the equator on the other, it cannot help being somewhere very near to a golden mean between the far too hot tropics and the far too cold arctic and antarctic circles; while at the same time it receives *more* sunshine, more vivifying influence to man than any other latitude by reason of its paucity of clouds combined with the high solar altitude."

The mean annual temperature of the Egyptian plain of

latitude 30° he admits to be a little above the mean of that latitude generally; but this, he says, is corrected by the hypsometrical elevation of 4,297 inches of the king's chamber above the sea level. This true mean temperature he places at 68° F. = 20° C., or one-fifth exactly of the distance on the thermometric scale between freezing and boiling water; and this is the temperature which the inner chambers of the pyramid, sheltered by the vast thickness of the rock around and above them, were designed to maintain.

The pyramid was further intended, according to the modern expounders of its teachings, to instruct men as to the mean specific gravity of the earth. It appears from a comparison of the various results of modern scientific investigations of the earth's density, that the specific gravity of the entire planet is probably 5.7. But when the cubic contents of the coffer (the pyramid unit of capacity) are divided by the tenth part of the cube of fifty inches (two sacred cubits), which is 12,500, the result is exactly 5.7. The logic of the argument is not quite clear, but the arithmetic is unimpeachable.

In connection with specific gravity, another curious proposition is stated by the disciples of the pyramid faith, which is that the total weight or mass of the pyramid, estimated in pyramid tons (a pyramid ton equals 2,500 lbs. avoirdupois) bears the round decimal ratio to the total mass of the earth of one to one thousand million of millions—1 : 1,000,000,000,000,000,000. In calculating the pyramid's mass, due account is taken of the cavities in the interior, of the different kinds of stone employed in its construction and the quantities of each, with their separate specific gravities. In the computation of the earth's mass, also, due account is taken of the spheroidal figure, and of the mass of the land above the mean sea level. No exception can be taken to the methods employed in these calculations; but the result, though curious, seems to be without any practical importance, and certainly shows no evidence of design.

It is a further article of the pyramid faith that, by the peculiarities of its construction, this monument marks the date of its own erection. It is truly Oriented to the cardinal points of the compass, and a vertical plane through the axis of its inclined entrance chamber is very closely near to the true meridian. This passage also inclines downward at an angle which, from a mean of many measurements, Professor Smyth

gives as 26° 27′. From below upward it therefore rises at the same angle. Its situation in the meridian and this inclination directed so nearly to the pole (which in this latitude has, of course, an elevation of 30°) has suggested naturally to many observers the idea that it was intended for the observation of what we call the pole star. But as this star is only about one degree and a third distant from the pole, while the axis of the passage is directed to a point 3° 33′ below the pole, it is evident that, to a person deep down in the passage, our present pole star cannot be visible at any time during its daily revolution. Since, however, owing to the precession of the equinoxes, the pole of the earth has a retrograde azimuthal motion on the ecliptic amounting to about 1° 23′ 40″ per century, it is certain in the course of between twenty-five and twenty-six thousand years to encounter or pass near every star in the northern heavens having a celestial latitude of about 66½°. Now it is a rather singular fact that, in the entire small circle of the heavens thus described, there is not a single star fulfilling this condition, and sufficiently conspicuous to attract attention and to be probably treated as a pole star, except one known by the modern name of Alpha Draconis. It is, indeed, true that there is another of great brilliancy, viz., Alpha Lyræ, a star of the first magnitude, which, at one point of the great precessional year, approaches the pole within a little less than five degrees, and so might answer, though rather imperfectly, the purposes of a pole star; but more than nineteen thousand eight hundred years have passed since Alpha Lyræ occupied this position, and even then it was out of the field of vision of the pyramid passage. Alpha Draconis, however, about four thousand years ago, was within 3° 42′ of the pole, and, at its lower culmination, could be seen by an observer anywhere in the entrance passage of the pyramid. But it is further held by orthodox pyramidists, that the *ascending* passage and the grand gallery were not without their astronomical use as well as the entrance passage, although they could only have been astronomically useful during the progress of the building and before they were covered up by the advancing masonry. The Pleiades were nearly opposite in right ascension to Alpha Draconis, at the time when the latter was the pole star; and Eta Tauri, the distinctive star of that cluster, passed the upper meridian almost isochronously with the passage of Alpha Draconis over the lower. The Pleiades were at that

time on the equinoctial colure, or at the right ascension 0°, and, as Prof. Smyth remarks, "this group of stars has been more bound up with human history, hopes and feelings, than any other throughout the sky." As the builders of the pyramid are presumed to have designed to mark by it the commencement of the great precessional year, they would naturally begin that year when the Pleiades and the equinoctial point were in the same meridian. The exact date of beginning was that particular day which, at the period named, must have come at some time during the year, when Eta Tauri was passing the meridian at midnight, while Alpha Draconis was in view through the entrance passage of the pyramid on the meridian below. Now there were two dates at which Alpha Draconis could have this particular distance from the pole—one at 2170 B.C., and the other at 3440 B.C. But it was only at the first of these dates that the two stars in question were thus opposed to each other in right ascension. The former, therefore, was the date at which the pyramid observers could determine the beginning of the great precessional year by observation through its chambers and passages, while the work was still in progress; and this it is which fixes the date of this foundation at 2170 B.C. The date of the foundation is said also to be recorded more directly and more distinctly by a mark in the descending entrance passage. It has been stated that the beginning of the Grand Gallery is regarded as denoting the date of the birth of Jesus Christ. From this point, 1542 inches measured backward brings us to the intersection of the passages, and 628.5 inches measured backward from this intersection lead to two strongly ruled lines directly opposite each other, on the sides of the entrance passage; which further distance added to the previous 1542 gives 2170.5, and brings us to the same point of time B.C. which has been deduced as above from the appulse of the star Alpha Draconis to the pole.

Many of the imputed properties of the pyramid, or of its chambers, passages and minuter parts, are here passed without notice, because though, by force of a great deal of arithmetical ingenuity, they are made to show some unexpected —perhaps accidental, perhaps intentional—relations, they have no important bearing on the question of divine guidance or inspiration, and can at most only serve to betoken, on the part of the builders, some acquaintance with scientific truths of which we have supposed the people of so distant a gener-

ation to be ignorant. Thus, in the proportions of parts and the assignment of dimensions we are told that the pyramid has a pervading character throughout of what is called *fiveness*, of which the first illustration is found in the fact that it has five solid angles, and five sides (including the base). But though fiveness is the ruling arithmetical character, other numbers share in this honorable distinction. Thus Prof. Smyth remarks that "though in a lesser degree than five, *four* may be considered a pyramid marked-out number; because four is the number of sides of the square base, and four is the number of the triangular faces and flanks." "*Three* and *seven*," he goes on to say, "have likewise been suggested by William Petrie as numbers connected with the Great Pyramid. Though, too, at present these numbers are only to be dimly seen in a rather abstruse manner (notwithstanding that they are general and universal to the whole surface), yet they have the discriminating merit of belonging to the Great Pyramid only, of all the pyramids of Egypt and the world." ["Antiquity of Intellectual Man," p. 200.] Since *two* and *eight* may be considered as implied in *four*, since six is implied in *two* and *three*, and since nine is the square of *three*, it would seem to be the singular privilege of this remarkable structure to derive a peculiar character from every one of the nine digits.

But the property of the Great Pyramid which is put forward first of all by Mr. John Taylor and Prof. Piazzi Smyth as offering perhaps the most indisputable evidence of the preternatural knowledge and divine guidance of the builders, is that it is what is called for the sake of brevity a π Pyramid. By this is meant that its vertical height has to the perimeter of the base the ratio borne by the radius of a circle to its circumference: a ratio expressed by $1 : 2\pi$; π having the well-known value of 3.14119. This is a property which is independent of the magnitude of the structure, and of which the presence or absence can be ascertained with certainty, if it is possible to determine its angles. It rests, therefore, upon a very different foundation from the speculations which depend on measurements of the base dimensions, concerning which there is at present no certainty whatever.

The foregoing propositions embrace all the essential doctrines of the pyramid religion. Of the thousand marvelous details of curious numerical relations which have been discovered or imagined to exist between the various dimensions

of the chambers, the ante-chamber, the grand gallery and the mysterious coffer, no account has been taken, because, whether true or otherwise, they are not above a moderate human intelligence, and have nothing to do with the question of inspiration.

I now propose to look into the facts upon the basis of which this extraordinary hypothesis has been erected. And, in the first place, as to the unit of linear measure which is asserted to possess at once these three characteristics. 1. It is the one ten-millionth part of the earth's polar radius, or one twenty-millionth part of the earth's polar axis. 2. It is in length exactly equal to 25.025 British inches. 3. It is identical with the sacred cubit of the Israelites. Unfortunately for the proposition under consideration, it is hopelessly weak in each of its three legs. There is no evidence, in the first place, that the builders of the pyramid used, or intended to use, any such unit of measure as the ten-millionth part of the earth's polar radius. History furnishes no testimony to this fact. Tradition is equally silent with regard to it. The builders themselves have left no record of it, in the form of inscription or otherwise. The proposition is a mere guess of Prof. Piazzi Smyth, to which he appears to have been led by a train of thought which he himself describes as follows,—the statement is condensed from his work above cited "Our Inheritance," &c., pp. 28, 29. Though his own words are not cited in full, no injustice to the sense is done in the abridgment. He asks himself what numbers in a π pyramid will express the ratio of linear height to twice base-breadth more simply than π itself with its inconvenient decimal; and he finds such numbers in the ratio of 116½ : 366. This number 366 appears to him suggestive. It is the nearest even number of days in a year; "or more precisely," he remarks, "of solar days in a mean tropical year." Now it appears that the side of the base of the pyramid, measured between the sockets which mark the places of its original corner stones (now wanting) both by the French scientific commission in 1799, and by Col. Howard Vyse in 1837, when it comes to be divided into 366 parts, seems to give to each of them a length approaching nearly to one ten-millionth of the earth's semi-axis of rotation. Equivalent, therefore, if further and independently proved, to the architect having laid out the size of the Great Pyramid with a measuring rod twenty-five inches long in his hand, and

in his head the number of days and parts of a day in a year; coupled with the intention to represent that number of days in terms of that rod on each base-side of the building. This is really the whole of the argument.

The suggested division having been made, gives for the French measurement a quotient of 25.037, and for that of Col. Vyse, 25.049. Both are too large for the purpose, and both become still larger, if, instead of dividing by 366, we use as a divisor the exact length of the tropical year, viz., 365.2422, which will give us, in the first case, 25.0886, and in the second, 25.102. The "further and independent proof" necessary was therefore looked for in measurements of the pyramid by other persons, from which a more satisfactory quotient could be derived; the quotient wanted being the ten-millionth part in British inches of another quantity quite unknown, but guessed by Prof. Smyth to be equal to 250,250,000 British inches. The quotient wanted was therefore 25.025. The only measurements of the side of the pyramid's base, besides those just named, which can be esteemed of any value, were made by Messrs. Aiton and Inglis, two British civil engineers, in 1865, and by surveyors belonging to the Royal Ordnance corps of Great Britain, in 1869. For comparison, all four of these measurements are here presented in a group, reduced to inches of British measure:

MEASUREMENTS OF THE SIDE OF THE PYRAMID'S BASE.

	British inches.
1. By the French academicians (north side, 1799)	9,163.440.
2. Col. Howard Vyse and Perring (north side, 1837)	9,168
3. Aiton and Inglis (mean of 4 sides, 1865)	9,110
4. Ordnance surveyors (mean of 4 sides, 1869)	9,130

The exact mean of all these measures is 9,142.86. But this, divided by 365.2422, gives a quotient of 25.0323, which is too large; and divided by 25.025 gives 365.35, which makes the year too long. It may be objected that the deviations from the result desired are here so slight that it is something like hypercriticism to demur to them. This consideration would be worthy of attention if the question before us were one of imperfect human accuracy; but when we consider that the builders were working under the guidance of divine and infallible wisdom, we cannot be permitted to doubt that the dimensions of the structure, as it left their hands, were true to the minutest fraction. We are compelled, nevertheless, to admit that

the modern measurements of this structure above given were made by fallible men. It is on this ground that Prof. Smyth is induced to guess, once more, that if a perfect measurement could be made it would be close to 9,140 inches [what is needed is 9,140.176045] for he remarks that "as there are *internal* evidences that none of these measures, not even the last, were accurate enough to be depended on to the third place of figures, all men are at this moment left by the last pyramid base side measures of modern times in this predicament, viz.:—the theoretical length of 9,140 inches, which would imply such almost unutterable wisdom, or such inconceivably happy accident, for that primeval time on the part of the designer of the Great Pyramid, is really found *among*, or as though it were *one of* the best results of modern measures." From which we are to understand that because the result desired is *not* among the best results of modern measures, therefore it *is* among them. For, as he continues, "The variations, therefore, first from 9,163 to 9,168, then to 9,110, and then to 9,130, must be merely the *plus* and *minus* errors of the modern measurers; or of men intending honestly to do well if they could, but erring involuntarily, sometimes to one side and sometimes to the other of exactitude."

In the discussions of pyramid questions there is a great deal of talk like this. The thing wanted is not found, but men would have found it if they had known how; it ought to be there, and therefore it is there.

One thing in regard to this base measure—a measure the correct ascertainment of which is absolutely vital to the pyramid religion—must have forcibly struck every reader of Prof. Smyth's voluminous works upon the Great Pyramid—it is that though he resided in 1865 for five months at the pyramid, living all this time in an ancient tomb within a stone's throw of the object of his study; and though, during this long period of time, he occupied himself day after day incessantly and most assiduously in the minutest examination of every square inch of the pyramid's surface, its chambers, and its passages; and though he measured, with microscopic accuracy, every facing stone of its interior in every part, including the dimensions, vertical, horizontal and diagonal, of all its cavities, and especially the famous coffer, of which he made a most protracted and wholly exhaustive examination; though, moreover, he prepared himself for this investigation by providing himself with instru-

ments of almost fabulous accuracy, among which were rods divided to hundredths of an inch, and corrected to thousandths, and an altitude and azimuth instrument with circles by the first of British artificers; and though the number of his measurements amounts to thousands, and the record of them fills an entire volume of his "Life and Work at the Great Pyramid," yet after all this protracted and patient labor, he came away at last without measuring the base side of the pyramid himself. Yet it was during his residence on the spot that the British engineers Aiton and Inglis visited Gizeh for no other purpose than to make this very measurement—the only measurement they were instructed to make at all—it was under his very eyes that they executed the work, the least satisfactory to him of all that have ever been made, but in the prosecution of which they proceeded with a thoroughness of which there had been no former example; having laid bare, for the first time, not two only, as the French academicians had done, but all four of the corner sockets; and having measured not the single northern side only, to which former measurers had confined themselves, but all the four sides; when, if they had been careless, he was there to detect their inefficiency; if they had been unskillful, he could not have failed to expose and denounce their incompetency; yet the result brought out by them in his own very presence gives, when tested for the value of the measuring unit, on the assumed sacred theory, the unsatisfactory result of 24.97 British inches. Why, when such an opportunity was afforded him as never before was presented to any measurer, when all the fiducial points of the base were exposed, when he was in possession of measuring instruments of an accuracy such as had never belonged to any previously applied to the purpose, and when the only reason for which he had visited the pyramid at all was to measure it, why did he not avail himself of these unexampled advantages to repeat immemediately after these blundering engineers had completed their task, the work which they had executed so greatly to his disgust? He has never pretended to answer this question. I do not see how he can answer it.

It is true that he has represented this measure as a very difficult one to make, because of the huge talus of broken rock accumulated on each side except at the angles, in consequence of the ravages made in past centuries by the reckless and ignorant inhabitants of the country, who have stripped these

majestic monuments of the earlier civilization of Egypt of their outer coverings for material to build the modern city of Cairo—accumulations which obstruct the view of one angle from another, and make measurement in a direct line between these points impossible. He has not told us what were the methods employed by the engineers whose measurements he witnessed; but we can suppose that they consisted in continuing the lateral lines of the structure parallel to each other to points where the rubbish heaps no longer intercepted the view, and then measured between the lines so produced. The only material error in the use of such a method would be in the possible deviation of the produced lines from true parallelism. But Prof. Smyth had a much better method open to him than that, if he had been disposed to use it. He is an astronomer by profession, and he had with him a splendid altitude and azimuth instrument, which he used to determine very exactly the orientation of the pyramid and the angular inclinations of its passages. If no two angles of the base were visible from each other, it was surely possible to find somewhere a point from which both could be seen. By planting the instrument at that point, and measuring the distances to it from each of the angles; and then with the instrument measuring the angle included between these lines, he would have had a triangle with two sides and the included angle known, from which the determination of the base would have been a simple operation. Or if any accidents of the ground should have made the direct measurement of long lines difficult, he would have measured a short base at a convenient distance from the pyramid, and by observing from both ends of this base he would have found the side desired by the same means by which he would determine the diameter of the moon. Such an operation, conducted with the skill of which Prof. Smyth is so accomplished a master, could not have failed to ascertain the quantity sought within less than an inch of possible error. The failure to apply this method, considering the relation of Prof. Smyth to the question to which so large a portion of the labor of his life has been devoted, cannot but be pronounced an omission entirely unpardonable.

It was an omission not only unpardonable, but also unaccountable, unless we adopt a supposition which, though it has a certain plausibility about it, I should be sorry to believe to be true, viz., that *he dared not do it*. I should soften, perhaps,

this expression, and say rather that he had not the heart to do it. For he could not but feel that on this crucial test would depend the fate of a theory which he had cherished for years as the very apple of his eye; and in view of the result of the measurement of which he had just been himself a personal witness, and which he was so far from impeaching that he has since said, in words already quoted, that it was made by "men intending honestly to do well if they could," he could not but feel an apprehension that, if he were to do this thing, it would be his cruel fate with his own hand to topple into ruin the beautiful edifice he had been so long, so patiently and so laboriously toiling to create. If it was a weakness to shrink from such a hazard, it was a human weakness, and we must feel ourselves constrained to pardon, though we may regret.

Mr. Taylor has a different method of connecting the pyramid with the Earth's dimensions. It partakes of that curious and unexpected character which distinguishes so many of his discoveries, and justifies us in classing them among what may be called the surprises of the pyramid. Taking as the true base-measure Col. Vyse's determination in feet (not in inches, as above), viz., 764, and making of this a vulgar fraction, with unity for the numerator, he reduces this to a decimal and finds the result to be 0.00,130,890,052, which is, he says, treated as a whole number, the mean circumference of the Earth in feet. "That is," as he expresses it, "one English foot bears the same ratio to the side of the pyramid that the circumference of the Earth bears to one hundred thousand millions of English feet." It must be confessed that, if the builders really designed to incorporate into the structure a record of their knowledge of the great geodetic truth here brought to light, they could hardly have devised a more ingenious mode of covering it up. The foregoing number, viz., 130,890,052, gives the mean diameter of 41,663,600, which reduced by one six-hundredth part on supposition of a polar compression of one three-hundredth part, makes the polar diameter equal to 41,594,160.66 feet, or 499,129,928 inches. Mr. Taylor introduces this statement with the observation: "This may be deemed nothing more than a numerical coincidence; but when we recollect that this foot alone expresses this relation, and that the measure by which it is expressed may possibly have had its origin at this time, and may even have been *called into existence to denote this proportion*, it seems to be a peculiarity which deserves notice." Nothing

could be more conclusive. There are, in fact, but two weak points in this argument: the first is that 764 is not the base measure of the pyramid, and the second that 130,890,052 is not the mean circumference of the Earth. Otherwise the reasoning is quite unexceptionable.

Incidentally deserving attention in this place is the discussion given by Mr. Taylor of the determination of the Earth's circumference by Eratosthenes—a determination presumed to have been founded on a direct measurement of an arc of the meridian extending from Syene to Alexandria, and which gave as a result 252,000 stadia, which, allowing eight stadia to the mile, as Mr. Taylor appears to do, gives 31,500 Roman miles for the circumference, which evidently indicates 10,000 miles as the diameter. The Roman mile being estimated at 4848.5 English feet, should thus give a circumference of 152,727,750 feet. Mr. Taylor adds: "But though Eratosthenes was wrong in assigning 31,500 instead of 27,000 Roman miles to the compass of the Earth, he was very nearly correct in stating the *proportion* which a sphere bears to its diameter, when he represents it by a ratio of 10,000 to 31,500. By his use of these figures, correctly if viewed in relation to the Great Pyramid, he shows that his knowledge was not derived from a new measure of the Earth, but from the proportions recorded in the Great Pyramid [in the fact, in short, that it is a π Pyramid]. Deducting *one-seventh* for his error, leaves 130,909,500 English feet for the circumference." That is to say, that because Eratosthenes made the circumference of the Earth to be 152,727,750 feet, or one-seventh too great, he would have made it, if he had not committed this blunder, 130,909,500 feet; so that his labors furnish the proof that this last is the true value. This reasoning addresses itself so directly to our intuitions that we are compelled to pronounce it irresistible.

Let us proceed to consider the second of the weak legs of our proposition, viz., that the unit of measure governing the exterior dimensions of the pyramid is exactly equal to 25,025 British inches. We have seen that this result cannot be obtained by applying the year-length theory to any of the direct measurements of the object itself. Shall we be more successful in regarding it as an aliquot part of the Earth's polar axis? The length of the polar axis of the Earth is a quantity which may with strict truth be pronounced to be, up to this time, absolutely unknown. It is a quantity not by any means easy to

be ascertained, and which in all probability mankind will never exactly know. To measure it directly is obviously a physical impossibility. All that we can know about it is conjecture, dependent upon uncertain calculations of which the data are measurements made upon the surface of the planet. Such computations would, indeed, be sufficiently trustworthy, if the figure of the Earth were a regular geometrical solid; but the thing which the many measures thus far made of meridian arcs has taught us more emphatically than any other, is, that it has not that character at all. Till within recent years, the planet has been regarded as a regular oblate spheroid; on the ground first, that such is the necessary figure of equilibrium of a homogeneous plastic mass in rotation—and that the earth was once plastic cannot admit of a doubt; secondly, that, as a rule, the measured degrees of latitude on the Earth's surface are longer in the arctic than in the tropical regions; and thirdly, that the vibrations of the pendulum in different latitudes indicate that the center of gravity of the planet is more and more distant as we proceed from the higher latitudes to the lower. If the figure were geometrically perfect, the ascertainment of the length of its axis of rotation would be a very simple problem. All that would be necessary for its solution would be the measurement of two meridian arcs of a few degrees in length, in different latitudes—the more widely different the better. And it would be a matter of no moment whether these arcs were measured on the same meridian, or on meridians in longitudes widely different. After the earlier meridian measurements, the problem was attacked in full confidence of the truth of this hypothesis. The results, however, obtained from different comparisons proved to be discordant in the highest degree. Every two arcs combined gave a different value for the polar axis; the differences ranging from a few miles to sixty or seventy. It became evident that this method could not be successfully applied to meridians in different longitudes; but it was hoped that it would furnish more consistent results if confined to partial arcs of the same meridian. Even here, however, great anomalies immediately presented themselves. Col. Everest, the director of the great Indian meridian survey, in which an arc of twenty-one and a third degrees is divided into two sections, found that, when he compared the northern half of the northern section with the southern half of the same section, he found an ellipticity twice as great as when he com-

pared the southern half of the northern section with the whole southern section; and that the values of the polar axis obtained from these comparisons differed nearly thirteen miles. In comparing arcs of different meridians (of which some fifteen or sixteen have been measured in different countries), this eminent geodesist obtained about seventy-seven different results. Gen. de Schubert, of St. Petersburgh, in 1859, in making similar comparisons, obtained twenty-one discordant results, the largest and smallest values of the polar axis so obtained differing nearly seventy miles. He necessarily concluded that the Earth is not a spheroid, but still continued to regard it as a regular geometrical solid—that is, an ellipsoid with three unequal axes instead of a spheroid with two. On this supposition, he made a new investigation, confining himself to the three long arcs of India, Russia, and France. The values for the axis deduced on this hypothesis from the Indian and the Russian arc differed only about fifteen hundred feet; but those derived from the Russian and the French were at variance to the extent of more than thirteen thousand feet. He accordingly rejected the French arc, and combining the results from the other two, assigning to the Russian arc double of the weight of the Indian, obtained a value for the axis of 41,707,467 feet,[1] or 500,489,604 inches. Sir John Herschel, considering this rejection unwarranted, made a similar combination of the three determinations, giving each a value proportioned to its length, and found the larger value of 41,708,734.9 feet, equal to 500,504,818.9, which comes pretty near the value derived by Prof. Smyth. Mr. Airy, Astronomer Royal, of England, made, in 1830, a combination of all the arcs

[1] Not having immediate access to Gen. de Schubert's paper, the numbers here given are taken from a reprint in Davies' Report on the Metric System, New York, 1871, of a Lecture by Sir John F. W. Herschel. The deduction, however, does not accord with the data there given, which are:

Russian arc	(25° 20′)	giving 41,711,019.2 feet.
Indian arc	(21° 21′)	" 41,712,534.2 "
French arc	(12° 22′)	" 41,697,496.4 "

Reduced to inches, these are:

Russian arc	gives 500 532,230.4
Indian arc	" 500,550,410.4
French arc	" 500,369,956.8

The combination of the Russian and Indian arcs, giving double weight to the former, gives 41,711,524.2 feet = 500,538,290.4 inches.

which had been measured anywhere throughout the globe, and arrived at a result of 41,707,620 feet, or 500,491,440. Later, Prof. Bessel, proceeding on a similar principle, made the axis 41,707,314 feet, or 500,487,768 inches. Col. A. R. Clarke, chief of the mathematical department of the British Ordnance Survey, published in 1866 the results of a very laborious investigation of this problem, conducted on a new principle, and gave as his final result, 41,707,536 feet, or 500,490,432 inches. Now, although some of these determinations approach very nearly to the desirable number of 500,500,000, yet only one of them comes up to it, and the mean of them all, which is 500,492,732.8, is more than seven thousand inches too small. While, therefore, we may admit that the approximation is sufficiently close to justify a not unreasonable hope on the part of the zealous pyramidist, that it may yet be closer, and certainly in the present state of the question to tantalize him to a most provoking degree, we must pronounce it to be still unproven that the governing unit of measure in the base of the Great Pyramid, even if it were, as it probably is not, an aliquot part of the Earth's polar radius, is a cubit of 25,025 British inches.

We come now to the third weak leg of our proposition—it is the assertion that the unit of measure in the Great Pyramid's base is the sacred cubit of the Hebrews. We know, traditionally, that there was a cubit in use among the Israelites which was called sacred, though Smith, in his Bible Dictionary, makes no mention of such a measure; but we do not know what that cubit was, and it may be set down as very certain that it was not equal to 25,025 British inches. What we know on the subject is mainly due to Sir Isaac Newton, a man who, in addition to having been the most illustrious of the investigators of exact science that England has ever produced, was probably the most profoundly learned in sacred archæology of the men of his time. In a dissertation on Cubits, and especially on the Sacred Cubit of the Hebrews, originally written in Latin, and translated and published in 1737, in the miscellaneous works of Prof. John Greaves of the University of Oxford, Sir Isaac has gathered all the evidence that is to be found bearing on the question; and after careful study, has reached the conclusion that the sacred cubit of Moses was not greater than 24.9389, nor less than 24.7262 British inches; and that its probable value was 24.7552. Prof. Smyth cites Sir Isaac's dis-

sertation at length and with signal approval, but he differs from him in the conclusion reached, which he thinks should have been 25 inches with a slight addition. It should be remembered, nevertheless, that Sir Isaac was wholly unbiased by any preconceived views, and was simply and honestly in search of the truth. He had no pet theories to sustain, and no reputation at stake on the result of the inquiry. On the other hand, he was a man who for acuteness in sifting evidence, and soundness of judgment in forming conclusions, has probably never had a superior. All this can hardly be said with justice of the very ingenious writer who seeks to discredit him. But though there was no doubt a sacred cubit among the Israelites, so called probably because of its use in measuring sacred edifices and their furniture, all history and all tradition, even the Bible itself, may be challenged for evidence that there was ever a sacred cubit in any other sense—in the sense, for example, in which the pyramidists interpret the word—that is to say in the sense of a measure of which God himself defined the exact length and gave to them, as appears to be believed by this class of metrological fanatics, in the form of a material and visible prototype. The Jews of the present day have heard no such thing from their fathers; the Talmud is silent about it; and certainly there is no such assertion in the Bible, nor is there anything in that book which by any amount of straining will bear such an interpretation. The earliest mention of the cubit in the Bible is contained in the sixth chapter of Genesis, where particular instructions are given to Noah as to the dimensions to be given to the ark. The words are as follows: "Make thee an ark of gopher-wood; rooms shalt thou make in the ark, and thou shalt pitch it within and without with pitch. And this is the fashion which thou shalt make it of: The length of the ark shall be three hundred cubits, the breadth of it fifty cubits, and the height of it thirty cubits." And so on. We find here no such phrase as "The length of the ark shall be three hundred cubits, *according to the cubit which I give unto thee.*" There is no question of what a cubit is, or of how it came to be. It is mentioned as something which Noah knows well enough already, just as he knows gopher wood, the material of which he is to build the ark. There was certainly then at that time no divinely given cubit. Nor is there any reason to suppose that there was one later. In the instructions given to Moses for the ark of the covenant and

the tabernacle with its furniture, cubits are spoken of just as before—that is to say, as measures already familiar to Moses. In the description of Solomon's temple in 1 Kings, Ch. VI., the word is used in the same way, as it is also in Esther, Ch. V., when the height of the gallows on which Haman is to be hanged is stated. Yet if it had been a part of the divine purpose to make the use of a particular measure of length a religious duty of his people, it is inconceivable that there should not be found somewhere in the sacred volume of the law, a definition of the thing they were to use, set down in terms too clear to be mistaken. In the eyes of the pyramidists, the Sabbath is not more sacred than the sacred cubit; yet the duty of observing the Sabbath is enjoined all through the Pentateuch with endless iteration, while of the sacred cubit we are not even told that such a thing exists. And this is true of a book in which rules are laid down with the minutest particularity for the government of men's conduct in matters of the most trivial importance. For example, "Thou shalt make thee fringes upon the four quarters of thy vesture." "Thou shalt not wear a garment of divers sorts, as of woolen and linen together." "When thou buildest a house, thou shalt make a battlement for the roof, that thou bring not blood upon thine house, if any man fall from thence." Deut. Ch. XXII. "Thou shalt not muzzle the ox that treadeth out the corn." "Thou shalt not have in thy bag divers weights, a great and a small." "Thou shalt not have in thine house divers measures, a great and a small." Ib. Chap. XXV.

When we find injunctions like this last, of which the Scriptures contain many, denouncing frauds accompanied by the use of false weights or false measures, how happens it that the sacredness of God-given weights and measures is nowhere appealed to, as constantly happens in denunciations of violations of the Sabbath? The answer is obvious. There never were any God-given weights and measures. All the weights and measures that were ever in use among men were equally of human origin, and in that sense equally profane.

I have said above that there is not a passage of Scripture which even by a strained construction can be interpreted to give evidence of the divine origin of the sacred cubit. There is, perhaps, one which at a first glance might seem to form an exception to this sweeping statement. It is found in Exodus, Chap. XXV, v. 9, where these words occur referring to the

sanctuary or tabernacle: "According to all that I *shew thee*, after the pattern of the tabernacle, and the pattern of *all the instruments thereof*, even so shall ye make it." Here it is implied that visible patterns were shown to Moses for his guidance; and that these patterns embraced instruments which some may suppose to mean tools to be used in the work, among which very possibly, or it may be said probably, must have been a measure of length. But if we take the whole passage in its connection, this interpretation can hardly stand. For the patterns shown are those of the tabernacle and the instruments *thereof*—that is, the instruments belonging to it and to be used in it—and not instruments to be employed in making it. But whether this be so or not, if we suppose the cubit to have been among the "*instruments*," we must accept the logical consequence that, before Moses, there was no sacred cubit; a consequence nothing less than disastrous to the pretension that this same sacred cubit was used in laying out the pyramid; since, according even to the chronology of Prof. Smyth, the pyramid was built at least seven hundred years before the Exodus, and, according to that of Bunsen and Brugsch more than sixteen hundred.

But though it is thus made morally certain that there never was any unit of length divinely imposed upon men for their use, and that the cubit governing the measurements of the pyramid's base was not a cubit of 25.025 British inches, nor the one ten-millionth part of the Earth's polar radius, yet there *was* a cubit of well-ascertained but very different length, which was unquestionably employed by the builders of the pyramid in every part of their work, external as well as internal. There is in the British Museum in London a double-cubit rule which was actually in use several thousand years ago at Karnak, and which, having been carelessly left by some workman in a closed cavity in the interior of a mass of masonry, was built up and preserved, until, by the dilapidation of centuries, its prison house fell to pieces, and it was restored once more to the light of day. This double-cubit measures just 41.472 British inches, which makes the single cubit equal to 20.736, a value already known as that of the royal cubit of Egypt; its length in the different buildings in which it has been used occasionally falling a little below that just given—a variation not uncommon and even inevitable in countries where a pretty sharp supervision and verification of the standards of measure and weight

in the hands of the people is not kept up by governments.[1] This Karnak rule exactly measures the breadth of the entrance and first ascending passages in the pyramid. Five times its length measures the breadth of the king's chamber, and ten times its length measures the length of the same chamber. Fifty times its half-length—that is the single cubit,—measures the distance from the beginning of the entrance passage on the north (supposing the pyramid restored to its perfect shape) down to the intersection of the passages; seventy-one times the same length measures the first ascending passage to the beginning of the Grand Gallery; ninety-one times the same measures the length of the Grand Gallery itself, and four times the same, its breadth; and, finally, taking the measurement of the base-side by Messrs. Aiton and Inglis as probably the best, four hundred and forty times the same cubit exactly measures the length of this important dimension on which the whole doctrine of the Divine Legation of the pyramid depends; leaving, therefore, no room to doubt that the same unit of measure was employed on the exterior just as certainly as it is admitted by the pyramidists themselves to have been employed within.

(*To be continued.*)

CRANES.

A REVIEW OF A TREATISE ON CRANES, ISSUED BY THE YALE AND TOWNE MANUFACTURING COMPANY.

BY F. R. HUTTON, C.E.

THE treatise under review is a book issued by the Yale & Towne Manufacturing Company, of Stamford, Conn. It would not be fair to characterize it as purely a circular. The subject receives a general treatment from a scientific standpoint, and the mechanical features which seem to commend themselves to the writer in that discussion are the features of detail which are chosen in the types illustrative of designs actually built and sold.

The general treatment is most complete. After explana-

[1] In some instances the royal cubit appears to have fallen below 20.6 inches. It is commonly stated at 20.7 or a little below.

tory introductions and contents, appears a paper from Vol. IV. of the Transactions of the American Society of Mechanical Engineers. This paper was presented at the Cleveland meeting of the Society in June, 1883, and therefore has been made free from any references to individual make or practice. It was received with interest and elicited some lively discussion. The paper refers to the fact that Glynn's old treatise and some modern British catalogues are almost the only text-books on this subject in English. The point is made that the availability of cranes cannot be appreciated where such little trouble is taken to find the saving from their use as compared with hand service. In many mills the saving is computed at twenty to fifty per cent. of their cost as the annual profit effected, and in many cases the crane would pay for itself in a year.

The *hoist* is a machine for raising and lowering weights. The added function of lateral motion for the weight makes a *crane*. Cranes are rotary and rectilinear, when classified as to the directions in which the load is moved. As to their movements as a whole, they are fixed and movable. As to the source of power, they are divided into hand-power, hydraulic, and steam. Of rotary cranes, the types are swing, jib, column, pillar, derrick, walking and locomotive cranes. The rectilinear cranes are bridge, tram, traveling, rotary-bridge cranes and gantries.

Having laid down these preliminaries as to nomenclature, the various details common to all are discussed in their order. For hoisting, the author approves of screw-gear, because of the compact reduction of speed and the safety against fall of the load with injury to the operators from the flying handles. In the discussion at Cleveland the frictional resistance of the worm-gear was brought out as an argument against it. It is also desirable that hoisting-gear should admit of two speeds —one rapid for light loads and for adjustment, and the other slower for heavy resistances. For the hoisting cord the author prefers chains, because it is possible thereby to eliminate the drum or barrel on which the slack is wound in. This drum is an annoyance with high lifts; the rope should be coiled on it but once, and to feed the rope to the drum requires either feeding guides or an oblique pull. With chain, a sprocket wheel can be used with guide and stripper, and no length of barrel is needed. The advantage of rope over chain

is that its structure distributes the strain over many fibers. In chain the stress is on each individual link, and no chain is stronger than its weakest link. With sprocket wheels, pitch-chain must be used, with all the links of equal length. Wire ropes require large drums and sheaves.

For the traverse gear for lateral movement of the load, a buggy or trolley is used upon the horizontal jib or girder of the crane. This should be so made as to allow horizontal motion without vertical change of height. It is convenient to have variation in speeds of this motion also. In the traveling cranes, beside the trolley motion, the girders themselves will also move, if possible, at different speeds. Here is introduced among others a special condition. The girders must be kept square with the rails, else one side will be derailed and the crane will fall. This may be done by driving both ends by a shaft bearing gears meshing into a rack by each rail. Or, as in the design under discussion, the two ends are made to move uniformly by wire ropes fixed at the ends of the shop, by which the girders are uniformly pulled along one way or the other. The same ropes pull the trolley across the bridge in one direction or the other. The end of the paper discusses the use of iron instead of wood for members of cranes, urging the advantages of iron.

Part II. of the book discusses the special construction of the details which the first part has shown to be preferable. It is illustrated with cuts of the chain-wheel, of the spur and worm-gear, of the safety ratchet and friction clutches, and reversing gear. Several of these features are most ingenious in mechanical conception, and well deserve study for their own sake. The multiplication of one load for frictional grips is most elegantly and simply shown. Then follow the devices for bridge propulsion, the "take-ups" for slack in the wire ropes, the system of wire-rope to furnish motive power, or hemp rope for the same service. A very graceful and well-proportioned hook for the hoisting chain is illustrated, and its standard dimensions are given in terms of the nominal load it may carry.

Part III. of the book is a description, with illustrations, of the various forms of crane built by the company, and Part IV. treats similarly of applications of the Weston differential or chain tackle, in plain hoists, in derrick winches and overhead tramrails or telegraphs, with single or compound rails.

Of course the scientific reader will find most to interest him

in the first part. In the discussion at Cleveland following the first reading of the paper, a series of features in traveling cranes was brought out by a gentleman who preferred the type originated by Appleby, of England. The particular feature of this construction is the replacing of the wire rope by a square shaft, as the means for conveying power to the crane. The square shaft is carried along the side of the building parallel to the rails, and the crane gearing takes its motion from it. The shaft is made up of lengths welded together, and supported by tumbling bearings, which the crane displaces as it travels, but which fall back in place when the girders have passed beyond them. By this plan is avoided the great reduction of speed from the high velocity of the wire-rope, and also the counterbalancing devices incident to the stretch and yielding of the endless cord. Screw gear is replaced by cut spur gear, with a gain of efficiency claimed for the change.

No reference is made at all to what may be called locomotive cranes, where the power is furnished by an engine and boiler borne on the bridge itself. This type is in use at the Baldwin Locomotive Works in Philadelphia, and in many places elsewhere. The smoke, gas and grit from the boiler unfit such a boiler for machine-shop use, but in sheds and in the open air it has manifest advantages.

Special mention must be made, in closing, of the hand-traveling cranes built under these designs. They embody some very admirable and ingenious devices, and would adapt themselves for many services where a power crane could not be made to pay for itself. The crab has all necessary functions, and the principle of securing different speeds is carried out very completely. The manipulation is all done by endless ropes over grooved wheels on the crab, and is quite simple. The attention of engineers has been also drawn to the system of discipline of operators which a traveling crane should entail. The operator should be guided entirely by motions of the hand of the foreman in charge of erection, and disorderly shouting should be quelled, as leading to mistakes and confusion. With a crane of good type, even the difficulties of foundry practice may be overcome, and the great advantages may be made the most of, which the traveling crane offers.

HERDERITE, A CALCIUM AND GLUCINUM PHOSPHATE AND FLUORIDE.

BY J. B. MACKINTOSH, E.M.

A FEW weeks ago, Mr. W. E. Hidden, of Newark, N. J., brought me some specimens of a mineral from the topaz locality at Stoneham, Maine, which, from its crystallographic relations, and from its physical properties, he determined to be the rare mineral Herderite. A specific gravity determination and qualitative test for phosphorus confirmed his conclusion, and as the mineral had never been analyzed quantitatively, I undertook to make the analysis.

Herderite is mentioned in all authorities as being an alumina, lime, phosphate and fluoride, but the results of my analysis show that there is no alumina present, the mineral being a glucina, lime, phosphate and fluoride, represented by the formula ($3\,CaO, P_2O_5 + 3\,GlO, P_2O_5 + Ca\,F_2 + Gl\,F_2$). The results obtained are:

FOUND.	CALCULATED FOR ($3\,CaO, P_2O_5 + 3\,GlO, P_2O_5 + Ca\,F_2 + Gl\,F_2$)
CaO....33.21	34.33
GlO....15.76	15.39
P_2O_5... 44.31	43.53
F.....11.32	11.64
104.60	104.89
Less O.. 4.76	4.89
99.84	100.00

The glucina was identified as such, both by its equivalent weight and by its reactions in the wet way when separated from the other constituents of the mineral.

These results are of interest as being the first recognized case of the occurrence of glucina in any other form of combination, except silicates and aluminates.

If the original qualitative analysis of herderite was correct in respect to the presence of alumina, then this mineral will be a new species; the probability, however, is that the qualitative analyst was mistaken, and that this mineral is herderite.

Further details regarding this mineral will be found in *The American Journal of Science*, for February, 1884.

THE CARPENTER CONTINUOUS AUTOMATIC AIR BRAKE.

By JUAN A. NAVARRO, C.E.

It may be interesting to the engineer readers of the QUARTERLY to have some data upon this brake, since the writer is assured by good authority that nothing until now has been published about it in America. The fact that the brake has been adopted by the Prussian State Roads, after a long and exhaustive competitive trial with six other systems, is alone a sufficient guarantee that it possesses merits.

The competing systems of brakes in the trial were (according to the official report which appeared in the *Centralblatt der Bau Verwaltung*, January 27, 1883, No. 4, p. 33, under the title "Einführung continuirlicher Bremsen bei den preussischen Staatsvalmen") the following:

"1. System Heberlein—Automatic friction brake" (worked by means of friction drums on the axles of the carriages.)

2. System Westinghouse } Automatic continuous air
3. " Carpenter } brakes.
4. " Steel.
4. " Saunders automatic vacuum brake.
6. " Smith Haardy simple vacuum brake, (similar to Eames vacuum brake, used on the N. Y. Elevated R.R.)
7. " Ordinary hand-brake.

"All of these, with the exception of the last, have patent rights."

Some of the merits claimed for the Carpenter brake over other compressed air continuous brakes are:

1. Simplicity of mechanism and parts.

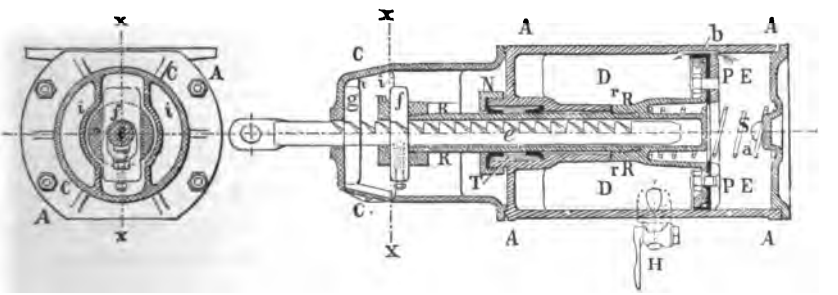
2. Avoiding separate reservoirs under each car or operating valves.

3. Automatic pull-rod adjustment, which sets itself every time that the brake shoes have been worn down 3 to 5 millimetres. (This is one of its most ingenious features.)

4. Quick action when needed, as the air-brake cylinder has been reduced to a minimum, by the automatic rod adjustment, without, however, too much sensibility. The action of the

brake requires at least an atmosphere's reduction of pressure; hence small accidental leaks have no effect upon it, though the breaking of a coupling or pipe would at once set the brake in action, as in all other automatic systems.

The description will be limited to the brake-cylinder with its automatic brake-rod regulator, as the parts which essentially differ from other compressed air systems. In the Carpenter system are also used an air pump and a large air reservoir 1,200 millimetres long and 600 millimetres in diameter, attached to the engine, in which the air pressure is carried up to 6–7 atmospheres, but no separate reservoir is used under each car. In the brake-tubes and cylinders, however, the pressure is constant, and never exceeds 4 atmospheres, this being effected by an automatic pressure-regulating valve on the engine. The object of this is to make it possible to carry higher pressure in the engine reservoir than what is needed to work the brakes, and thus to have an extra supply of air for all emergencies. The brake can, however, be worked without this regulating valve, which is not at all an essential part of the mechanism.



The working of the brake is as follows: A A A A is the brake cylinder, which is divided by the piston P P into two chambers D D and E E. Compressed air from the reservoir in the engine is admitted through the opening *a*. This has the effect of pushing the piston forward till it acquires the position in the drawing. The compressed air then enters through a small groove *b*, one millimetre square, into the chamber D D (or should the groove accidentally be stopped up, the air would force its way between the walls of the cylinder and the leather packing of the piston, since the leather is turned in the proper direction) until the air tension on both sides of the piston becomes the same. The piston will now maintain this position because on the side E E, besides the additional pressure of the

spring S, the air pressure on that side is greater than that on the opposite side D D, since the area on this last side is less than the former by an area equal to a section of the piston rod R R, which is exposed to the atmosphere. The air can be suddenly allowed to escape from E E by means of a three-way cock on the engine manipulated by the driver, which permits the brake-cylinder either to be put in connection with the air reservoir or with the atmosphere. The air will try to force its way from D D to E E through the groove *b*, since between the packing of the piston and walls of the cylinder it is now impossible for the air to pass, the leather packing being turned in the wrong direction. As the section of the groove, however, is very small, the reduction of pressure in the chamber E E is much greater, and takes place quicker than it does in D D, and, as a consequence, the expansive force of the air in D D pushes the piston backward when the groove is cut off, allowing the full expansive force to act upon the piston, and therefore upon the brake rigging. This is attached to the pull-rod *e* which plays inside the hollow piston R R, and is attached to it by the plate *f*, working upon the ratchet of the rod and held by the piece *m* screwed on to the end of the hollow piston rod.

To loosen the brake, compressed air is again admitted into the chamber E E, when the piston will run back and resume its former position notwithstanding the compressed air in D D, on account of the before-mentioned reasons of the spring S and the greater area on the side E E; notwithstanding also that the air tension on this side must be slightly higher than that in D D, on account of the small loss which takes place at the beginning of the operation through the groove *b*.

It is also clear that in applying the brake, the force used can be regulated by relieving the chamber E E of more or less pressure, since the force with which the piston is impelled is always proportional to the difference of tensions existing between the two chambers of the brake cylinder.

One of the unavoidable features of the brake is, that having play of air on both sides of the piston, the piston rod needs packing. To fulfill this need, two contrivances are used: a stuffing-box proper, consisting of two leather cups placed in opposite directions and the space between, T, filled with tow soaked in grease, the whole being tightly compressed by a large screw nut N; and a rubber ring *r r*, which when the brake is out of use, the greater part of the time, relieves the stuffing-box.

Further, the piston rod is protected by the casing C A A C from dirt or grit of any kind which, settling on it, would tend to wear it loose; but should it become necessary at any time to change the packing, this is easily done by unscrewing the casing C A A C and slipping it out over the rod, which leaves the stuffing-box within reach by unscrewing the nut-head N.

The contrivance, it is claimed, works so well that until now (nearly a year's time) not a single leak of the stuffing-box has been complained of.

To understand the automatic pull-rod adjustment, it must be kept in mind that under given conditions the following parts are free to move from one to another: the brake pull-rod *e*, the piston-rod R R, with piece *m* which is screwed fast to its extremity, the piston regulating-plate F, and the pull-rod regulating-plate *g*. Both of these latter are metal plates hanging on the ratchet, the former held in place by means of a rod and spring underneath it, while the latter hangs loosely, being kept in place by its weight. Both have, moreover, a longitudinal opening underneath, so that they can be slipped up the ratchet forward. The plate *g* is broader than *f* and can only play between the inner wall *h* of the casing and *i*, while *f* can go up as far as the piston-rod pulls it. Under normal circumstances, the distance *h i*, minus the thickness of *g*, is such that it is equal to or less than the distance which the piston runs, on putting on the brakes. After a while the brake shoes wear out and the brake rigging has a longer stroke and consequently the rod *e* runs over a larger space than that which the plate *g* can. So long as the difference between the two distances run is less than the pitch of the ratchet-teeth, the only effect of this is to force the plate *g* up on the tooth on the forward journey, slipping down on the same tooth by its weight on the return journey of the rod *e*. Just as soon, however, as the wear of the brake shoes is such that the difference between the distances which the piston-rod and the plate run equals the pitch of the ratchet teeth, then the plate *g* will be forced far enough up to fall into the next ratchet tooth, and on the return journey will naturally reach its limit *h* before the piston-rod; and as the plate *g* cannot move backward on the ratchet, it has the effect of holding the rod *e* fast. The piston-rod, however, continues moving, pushing the plate *f* in its turn up the incline of the ratchet until it falls into the next tooth in front, the spring underneath the plate giving it stead-

iness. Things stand now as at the beginning, although the rod *e* is the pitch of a tooth farther in. To make sure that the plate *f* will always fall into the next tooth when the plate *g* has done so, a small lead of some millimetres is given to *f*.

In this way the wear on the rod *e* is reduced to a minimum, as the only rubbing which takes place every time the brake is put on (leaving aside that of the stuffing-box) is that between the loose plate *g*, weighing about 2 kg. and the rod *e*. The plate *f* moves only each time that the wear makes it necessary, and even then only with the pressure exerted by its own weight and the elastic force of the spring underneath it, as the movement takes place on the backward journey of the piston, when the rod *e* is fixed and not under strain.

In order to pull the brake-rod out again when it has reached its limit of action, all that is necessary is to detach it from the rigging and turn it 180° around its horizontal axis. The plates are kept from turning by their longitudinal form and narrowness of the space in which they are, when the rod will present its smooth side to the plates, allowing, therefore, the slipping out of the rod for the required length. The ratchet on the under side has no influence, on account of the grooves cut in the plates. The rod can then be turned to its primitive position and attached to the rigging again.

The cock H is to allow the air to escape out of the front chamber of the cylinder, in case the brake, from improper handling, should remain in action after the car has been detached from the engine.

STANDARD TIME.

By J. K. REES, A.M.

ON November 18, 1883, there was accomplished virtually a reform in the Time Standards of the United States and Canada for which scientific societies and men had long been working. On account of the labor done by the American Metrological Society, followed by the Society of Civil Engineers and the American Association for the Advancement of Science, and especially because of the prompt and very energetic work of Mr. W. F. Allen,[1] this reform was quietly begun.

[1] Editor of the Traveler's Official Guide and Secretary to the R. R. Time Conventions.

There has been but little opposition to the new standards as their scope has been studied. The newspapers have given such full accounts of the movement that it will be necessary here to make only a short statement. In France the railroad systems are run by Paris time. The greatest difference between the true local time and the railroad time is over forty minutes. In England, Scotland and Wales but one time is used, and that Greenwich time, while the extreme points, Yarmouth and Land's End, are thirty-two minutes apart. The adoption of one time standard for a large section of the country, and the consequent abolition of the numerous local time standards, is attended with great and obvious benefits.

So far as I know, the first person to publish any system for the United States was Prof. Dowd, of Saratoga Springs, who, in 1869, published a pamphlet explaining his "hour system" for the railroads. Prof. Dowd proposed to take belts fifteen degrees wide, running north and south through the country, and to have all the railroads in a belt keep the same time. These belts being fifteen degrees of longitude in width, the time standards would thus differ exactly one hour. He first started with the meridian through Washington, D. C., as his initial central-meridian, but afterward changed his system so as to connect with the meridian of Greenwich, by adopting as his initial central meridian the 75th meridian west of Greenwich.

Prof. Dowd met many of the railroad men, and, although influencing a few of the prominent railroad managers, he was not able to bring about any practical result, except, perhaps, to educate a considerable number of railroad men in the advantages of his system. In 1874 the Standard Time Committee of the American Metrological Society took up the subject, and, without being aware of Prof. Dowd's work, elaborated a system of "hour standards," basing their system on Greenwich, and dividing the United States and Canada into north and south belts. This society printed considerable matter on the subject, and through the energetic work of President Barnard, Cleveland Abbe and E. B. Elliott, succeeded in stirring up a great deal of interest. It was through the influence of this committee that Mr. Allen became a member of the American Metrological Society. Subsequent to the beginning of the work in this society the subject was brought to the attention of the Society of Civil Engineers and also the American Association for the Advancement of Science. Many of the

Directors of Observatories in the United States became thoroughly interested in the proposed reform, and aided materially in educating the people up to a comprehension of the scheme and its avdantages.

But while the "hour system" scheme was endorsed by the majority of scientific men, yet there were those who favored a single standard for the whole country. This standard meridian some proposed to pass through Washington, while others suggested the 90th meridian from Greenwich, which passes about 50 seconds to the east of St. Louis. The scientists fully appreciated that the key to the solution of the problem lay in the hands of the railroads. If the railroads should adopt any system, the people would very soon follow. Therefore many attempts were made to interest the railroads, without any practical result, until the American Metrological Society interested Mr. Allen in the matter, to whom the railroads had referred the question. Mr. Allen very quickly decided that it would be of no use to press upon the railroads any single-standard system, as the country was too large; and he also decided to recommend any system that should turn out to be practically the best for the railroads without considering the scientific side of the question. In studying the railroads he soon saw that the hour system was the best, and that the roads were arranged in four belts. Roads east of Buffalo, Pittsburgh, Wheeling, etc., ran on various times, of which Philadelphia time was nearly the average. Roads in the belt between Pittsburgh and the western boundary of the State of Kansas had standards of which St. Louis time was nearly the average. Roads between Kansas City and Salt Lake adopted Denver time, and still farther west San Francisco time was used. Noticing how close to the standards suggested by the American Metrological Society his practical standards ran, Mr. Allen proposed to the railroads to adopt that plan. Making a careful study of the whole country, he selected the points at which it was feasible to change from one hour standard to another. After months of writing and incessant labor, the majority of the railroads were persuaded to join in the movement. After the railroads were secured, it became desirable to have the principal cities in the country adopt the new standard time. In our own city the writer was fortunate enough to meet with Gen. Cochrane, of the Law Committee o the Board of Aldermen. To this gentleman the proposed change was explained, and in a subsequent meeting at the City

Hall. Gen. Cochrane, with Mr. Allen and the writer, drew up a

Directors of Observatories in the United States became then

Hall, Gen. Cochrane, with Mr. Allen and the writer, drew up a preamble and resolution embodying the change. This was passed without trouble, owing to the favorable view taken of the proposition by Gen. Cochrane and Mayor Edson. In Boston, the action of Prof. Pickering, of the Harvard Observatory, and his assistant Mr. J. R. Edmands, overcame all opposition, and a change of 16 minutes was made in their local time. Since the action of these two cities, many of the large cities in the country have adopted the standards of the belts wherein they are situated. We place before the reader for reference copies of Mr. Allen's map.

Even after the system shall have been universally adopted in this country, the complete plan of the foremost advocates of the changes in time standards will not be carried out; for they propose encircling the globe with standard meridians fifteen degrees apart. All places seven and one-half degrees east and west of a standard meridian would approximately, governed by limitations of nationality, adopt the time of the central meridian, so that as one should travel around the earth he would find the local times differing exactly one hour.

Moreover, it is proposed to have what is called a Cosmic Time. The Cosmic day is to begin when the mean sun is over the meridian 180° from Greenwich. It is further proposed to do away with the A.M. and P.M. designations, and to number the hours from one to twenty-four.

Through the work of the American Metrological Society and the Society of Civil Engineers, the knowledge of this complete plan for the world has been spread abroad. The general plan has had the endorsement of the Geographical Convention which met at Venice, the Society for the Reform and Codification of the Laws of Nations at Cologne in 1881, the Imperial Society at St. Petersburgh, the Geodetic Convention at Rome, the International Bureau of Weights and Measures at Paris, the Canadian Institute, etc., besides most of the scientific societies in his country. In order to further discuss this subject in its world-wide application, the President of the United States, acting at the request of a large body of scientific men, has called an international convention to meet at Washington in October.[1] Judging from the interest shown in the question by all the leading nations of the earth, we may confidently expect to see the world-wide adoption of the hour-standard system in the near future.

1 It is to be hoped that this date will be changed to a much earlier one.

THE PRESENT ASPECT OF ORE-DRESSING IN EUROPE.

(*Concluded from p.* 34.)

By W. B. KUNHARDT, E.M.

Losses in Wet Dressing.—By observing suitable precautions both for minimizing the production of dust in hand-sorting and crushing, and for saving whatever mineral is comminuted in those operations, the losses in dressing ore classes of nut, pea, and coarse sand sizes have, in present practice, been reduced to a minimum for all ores in which the difference between the specific gravities of the constituent minerals is sufficient to insure the success of ordinary dressing methods. In the treatment of coarse ore, the only mineral or metalliferous portion, so-called, that actually goes to the waste dump is such as is locked in barren products from hand-sorting and jigging—material which, by simple calculation, is found too poor to be profitably subjected to the further processes of slime treatment.

In slime dressing the mineral losses have been reduced by substituting new comminuting mills for stamps, and by introducing continuous processes of concentration in which the production of dry float mineral is avoided. The middlings and tail products from the slime tables are re-washed as often as they will pay for the treatment, but nevertheless the losses continue to be very high. At Clausthal, where work is particularly directed toward obtaining clean tailings, rather than high grade concentrates, the average contents of the ore subjected to stamping and washing are 3–4 per cent. of lead; the waste tailings are not regularly assayed, but their mineral contents are estimated by the difference between the percentage of mineral in the ore and the quantity obtained in the concentrates, and such calculation has shown repeatedly that the loss amounts to fully 50 per cent., and is frequently nearer 60 per cent. of the mineral carried in the crude slime. Results obtained in a number of leading mills show that the dead slimes run 24 per cent. of lead, and that the losses range from 45 to over 60 per cent. of the mineral contained in the crude slimes. Such figures raise the proportion of total losses incurred in the

whole course of dressing to 12–16 per cent. of all the mineral in the ore.[1]

From time to time brief statements appear in the technical journals to the effect that some mill has increased the capacity of its tailing basins, or has begun to wash fine pulp that had formerly been discarded. So, for example, it is noted that additional large round tables have been put into operation at Clausthal, and these collect from the finest settlings of a very extensive labyrinth forty-six pounds of concentrate, running 50 per cent. of lead, per cubic meter of pulp. The cost of the washing is found not to exceed 12½ per cent. of the value of the concentrate obtained from what heretofore has been a waste product. Fifty per cent. of the mineral of that product is now saved by the new, extended washing facilities, and the final tailings to-day carry a little less than 2 per cent. of lead—a result which is as good as any that has come to the writer's knowledge. Such journalistic notices indicate that the managers of dressing works are alive to treating all material that can possibly yield a profitable return with existing methods and with the means at their command. Losses, then, can rarely be ascribed to neglect in practical working, and so it remains to trace them to defects inherent in the prevailing systems of concentration.

One of the most thorough investigators in the field of ore-dressing has been Sparre, a Prussian mining official, who devoted much of his time to slime-washing, which is the most difficult branch of the subject. He experimented with an inclined glass table, of small, model size, inclosed in a glass tube which formed one arm of a V-shaped pipe, with flexible, rubber joint. With this apparatus he was enabled to regulate the velocity of a flow of water or of slime over the washing surface independently of its inclination.[2] He used the apparatus to confirm his theoretical investigations, and he demonstrated that when ore particles of the same specific gravity are exposed on an inclined plane to a shallow stream of water, a certain dip[3]

[1] The best American practice can point to a saving of 90 per cent., or sometimes of even a greater proportion, of the mineral carried in the ore, even when it is in a state of very fine dissemination, but in making comparisons with foreign practice, the very low grade of most of the foreign ores must be borne in mind, and only the absolute (not the relative) losses should be considered.

[2] *Sparre*, Zur Kritik der Separation, p. 26.

Althans, Judges' Reports on the Centennial Exhibition, Vol. I., p. 228.

[3] This dip is not to be confounded with the angle of repose in cases of sliding friction.

of the washing surface will be found which allows the particles of one particular diameter to offer the greatest resistance to the current—or, differently expressed, with a gradually increasing velocity of current, but with a constant dip of the table, all the particles which are either larger or smaller than those of one special size, will be carried off the table, while the grains of this one-size class will remain deposited, and can only be removed by a still further increase of the current after all the other material has been washed away. The angle or dip of maximum resistance increases as the size of the particles diminishes. For a given ore-size, this angle is independent of the specific gravity of the grains; but the minimum current velocities which, for any given dip of the table, suffice to carry two equal-sized grains of different specific gravities off the washing surface are proportional to the square roots of those specific gravities. In sizing a class of equal-falling ore grains on the experimental washing table of glass, the larger (specifically lighter) particles could be separated from the smaller headings with a minimum quantity of water by setting the dip of the washing surface at the angle of greatest resistance of the smaller size class.

These important principles, demonstrated by experiment, could not be directly incorporated in a washing machine designed for practical use, because the washing surface of such an apparatus would have to be covered over, and so by precluding all observation would prevent adequate control of the separation. Sparre, in his further studies, concluded that the most practical way for establishing an independence between the dip of the washing surface and the velocity of the water current on a continuous machine, lay in the use of an open or uncovered table, to which a continuous or intermittent rotary motion should be imparted. This motion, communicated to the slime, could be accurately regulated on a table of any dip so as to develop in each ore grain a certain centrifugal force, which, combining with the force of gravity acting in the direction of the dip, would produce a definite resultant for each different class of grains, and so permit of a good separation. Through practice it was soon made evident that the dip of the table should not be great, but rather so calculated that a

[1] A continuous motion proved best for washing hydraulically sorted, or graded, material, while an intermittent motion was preferred for the treatment of fine, graded slime.

moderate centrifugal force would suffice to produce the necessary resultant. An intermittent oscillating table,[1] designed on Sparre's principles, is reported to have produced excellent results, but the machine has never obtained prominence.

None of the prevalent types of washing tables fulfills the conditions shown by Sparre's theories and experiments to be essential to the best attainable results in slime washing. Everywhere the dip of the tables is used to regulate the velocity of the current which flows over them, and it cannot, therefore, serve to control the rolling motion of the ore particles. The angle of inclination is smaller than what Sparre found most suitable when the velocity of the current was independent of the dip, and since on ordinary tables and vanners this velocity must diminish with the fineness of the slimes that are treated, the disproportion in respect to inclination correspondingly increases. In common practice the slime particles which are charged upon a smooth washing surface, pass over the greater portion of it with but an imperfectly governed sliding movement, instead of advancing with a definite, well-controlled rolling motion, and a course of many feet is required to complete a separation which a very much shorter space should easily accomplish. Blanket cloths and designedly roughened surfaces are frequently employed to prevent the sliding of the mineral grains. Their use for this purpose is attended with a certain degree of success, but they interfere in other ways with the efficiency of most separations.

Slime dressing, in the present state of its development, is clearly wanting in machines that incorporate all the principles upon which the art is based; there are at present no washing tables—or, at least, none such generally known or used—yielding results which can be regarded with complete satisfaction. Radical improvements must still be sought for, and these, developed in accordance with the principles above summarized, should lead to the design of smaller, less expensive and more efficient machines.

More than thirty years ago Pernolet noted that the laws governing the free fall of bodies in water do not hold good for very fine particles, on account of the increasing influences of the adhesion and viscosity of the water compared with the

[1] Constructed by the Humboldt Machine Shops (then Sievers & Co.) at Kalk, near Cologne.

weight of the small mineral body. This observation seems to have remained for a long time without fruitful issue in the treatment of fine slimes. Pulp is still washed on round tables in very much the same manner as coarse meals. The palpable result of so defective a system is found in apparatus of extravagantly large size, with small capacity and low efficiency. In view of these facts, the development of dry ore dressing,[1] at comparatively recent date, is particularly interesting. On general principles it is evident that a separating medium of high density is favorable in dressing operations when the influences of its viscosity and its adhesion to the ore particles are so small that they may be neglected.[2] When, however, adhesion and viscosity can seriously interfere with the movement of very small ore particles acted upon by gravity, the denser medium may with advantage be replaced by one that is lighter but less adhesive. In such cases "dry," or pneumatic concentration profits by the very slight adhesion of air to the ore, and in carrying out the separation on an air jig, there is no troublesome return current moving downward through the ore-bed, and practically no inertia of the separating medium to limit the speed of the machine. A speed of 500 strokes per minute has been attained and good separations effected. Pernolet found, in experimenting with bodies falling through water confined in tubes, that the resistances due to the walls of the tube were perceptible when the moving grain occupied only $\frac{1}{80}$ part of the section of the tube.[3] With larger grains, or with narrower tubes, the influence of the tube walls becomes more appreciable, and the laws of movement of the bodies are no longer those of unobstructed fall through water. At a much later date Bartlett pointed out in a very interesting paper,[4] how some of the remarkable results obtained by Krom in experimenting on pneumatic separations were effects of that same cause—namely, resistances due to the enclosing walls of

[1] By Krom, and Paddock, and others in this country.

[2] If the ratio of the specific gravities of two equal sized bodies be as 3 : 7, the ratio of their falling weights in water will be as (3–1) : (7–1) or as 2 : 6, showing a gain in the ratio in favor of hydraulic, over air, separation. In the case of saline water, such denser medium would be still more favorable for the separation, aside from the fact that salt water is more liquid (or less viscous) than fresh water.

[3] Pernolet; *Études sur la Préparation Méchanique:* Annales des Mines, 1851, tome XX., p. 564.

[4] Bartlett: *Action of Small Spheres of Solids in Ascending Currents of Fluids, and in Fluids at Rest:* Trans. Am. Inst. of Mining Eng., 1877–78, Vol. VI., p. 115; Engineering and Mining Journal, 1877, Vol. XXIV., pp. 102 and 129.

the air current; or, in other terms, he explained how a rising current of air in a narrow tube could easily separate two different mineral grains that were equal-falling in water, by the buoyant action resulting from a difference of gaseous tension in the tube above and below the larger, specifically lighter, grain which the air current sustained. The influence of the enclosing walls is preserved in Krom's pneumatic jig, but the delicate means of separation thus obtained necessitate correspondingly great uniformity of the blast and very accurate sizing of the ore. Slight variations in either of these quantities will change the whole effect of the air treatment, and this is one of the difficulties which has to be met and overcome in practice. Coarse ore cannot be dressed without air currents of very high velocity, and, moreover, since the important relative advantage of air over water—the slight adhesion of the former—disappears in treating all but fine material, it seems almost certain that coarse pneumatic jigging will be restricted to dry regions where water is expensive.

Air jigging has recently attracted some attention for the treatment of the finely mineralized tin ores of Cornwall. A promising field for it, although one in which several leaching processes have of late been successfully advancing, is presented in the dressing of gray copper and of fine, brittle sulphide and telluride ores carrying the precious metals—ores that cannot be treated without great loss on washing machines. As to the extent to which pneumatic concentration may in the future replace slime washing or modify the treatment in a "wet" mill, it would be premature, at present, to hazard an opinion. When the large mineral losses incurred with present methods are taken into account, and when it is also considered that even the most perfect slime washer, designed in accordance with the laws of the free movement of bodies in water and on inclined surfaces, could never treat pulp slime to complete satisfaction (for the very reason, as Pernolet has shown, that the pulp particles are not governed by those laws), then the necessity for some radical change appears to be very evident. Such change and improvement may in many cases be found in the adoption of pneumatic concentration, though certainly not before the new system has been further developed by careful study and experiment.[1]

[1] The practice now pursued in the West, of mixing with water the dust collected from dry concentration, and washing the resulting slime on vanners, is directly opposed to the essential condition to which air jigging should, it seems, look for success, namely, to the efficient dressing of extremely fine material.

Reference has been made in the course of this paper to special dressing operations based upon some particular property in the ore, other than the specific gravity of its constituents, and it now remains to give a short account of such processes, prefacing here that their introduction is still quite limited, but that the growing spirit of independence in experiment and practice promises further developments and a wider field for their application.

Calcining.—Very tough rock mined in large pieces is sometimes piled together with fire-wood in open heaps; light is set to the fuel, and when the ore is thoroughly heated, the fire is quenched with water. The rock is fissured or rendered "tender" by this treatment, and then is crushed with comparative ease. The practice of calcining, a very old one, prevails in the tin districts of the Saxon Erzgebirge, where finely disseminated tinstone is carried in a tough granitoid gangue.

A recent application of calcining is reported from Oberlahnstein, on the Rhine. A dressing product of blende and spathic iron is heated to redness, and then dropped into water; the spathic iron is thereby thoroughly disintegrated, and falls into very small particles; an easy separation by sifting then follows. This method promises to be a very useful and valuable one, though probably not applicable to ores of a very finely intermixed texture.[1]

Roasting.—An oxidation by means of roasting is sometimes resorted to after two or more mineral species of nearly the same specific gravity have been concentrated out of a common gangue, and are to be separated from one another. In Cornwall, for example, the concentrates of tin ore carry, after repeated buddling, 45–55 per cent. of tin, the balance being principally iron, sulphur and arsenic, in the forms of arsenical pyrites and spathic iron. The specific gravities of these minerals are—cassiterite, 6.4–7.1; arsenopyrite, 6.3; siderite, 3.9. By roasting, all the minerals but the tin are decomposed, and the roasted product consists practically of tinstone and very fine sesquioxide of iron. The specific gravity of the latter is 4.5–5.3, so that its separation from the tin by further buddling is quite practicable. A small proportion of stannic oxide, not over one-half per cent., is sulphated in the operation, and lost in the subsequent washing. At some of the mills the arsenic

[1] For further examples of calcination as applied to ore-dressing, see QUARTERLY, Vol. III., p. 55.

fume is saved as a commercial product. The oxidation is performed in a Brunton mechanical roaster, which has a circular, slightly conical, rotating hearth, set on a vertical axis in a round reverberatory chamber. The concentrates, after being well dried upon the roof of the furnace, are charged into a hopper from which there is a continuous feed on to the hearth; the latter moves with a speed of six to eight rotations per hour, according to the quality of the charge and the length of time that the same is to remain in the furnace. The material falls upon the centre of the hearth, and is heated to a dull red by two reverberatory fires. It is gradually moved outward, to the periphery of the hearth, by a set of fixed, horizontal arms, set radially and furnished with vertical flukes which stir the slowly revolving bed of ore. The discharge, by means of a scraper, is also continuous; the roasted ore falls into a closed receiver and is wetted down (to avoid arsenical dust) before further treatment. The ore requires six hours in passing through the furnace. The roasted concentrate is of light gray color, but shows the characteristic red of ferric oxide as soon as it is suspended in water. For a similar treatment of tin ore in Saxony, long reverberatory furnaces are used, but they certainly cannot be worked as economically as a mechanical roaster of which the Cornish furnace is one type.[1]

Another case of roasting, and one of special interest because it bears directly upon the difficult problem of treating concentrates carrying zinc blende and iron pyrites, is found in the ore-dressing practice at Iserlohn, in Westphalia. Blende and pyrites occur in many ores associated with other minerals; their specific gravities are respectively 4 and 4.9, and all efforts to effect their complete separation by mechanical washing have been practically unsuccessful. In ordinary dressing, a large proportion of these two minerals is obtained as one product, both from jigs and from slime washers, and though the concentrate may run high in zinc as well as in iron, yet the mixed product sells to no profit. At some dressing mills, even among the foremost, this product is discarded, or perhaps accumu-

[1] In some few cases roasting is combined with further chemical reactions; to remove the tungstate of manganese, wolframite, (sp. gr. 7–7.5) from the tin concentrate with which it is not unfrequently associated, soda is mixed with the ore, and in roasting a double decomposition takes place; sodium tungstate is formed and leached out with water. Salt has also been used with tin concentrates, chloridizing impurities of copper and furnishing an alkaline base for tungstic oxide. *Vide* Kerl, *Allgemeine Huettenkunde*, pp. 496–7.

lated on the chances of future realization. At Iserlohn the product in question is shipped a few miles by rail to zinc smelting works, and is there roasted. Almost all the blende is thereby converted into zinc oxide, and the pyrites into ferric oxide. The roasted material is jigged with a little care, and a fair separation obtained. The separated products find a ready market, and the mode of treatment is said to be profitable. In working the process, it has been found that the roasting should not be carried beyond a certain limit; 3 per cent. of sulphur must remain in the material after the roast, in order to preserve a certain coherence in the zinc oxide. But notwithstanding this precaution, a very appreciable amount of zinc is lost in washing the oxidized minerals, so that this method cannot be regarded as altogether satisfactory. The process was suggested by the finely crystalline, as well as closely banded, structure of the blende and pyrites. To disintegrate the ore by any ordinary mode of comminution would have necessitated a very fine reduction with the attendant losses. By the action of heat, however, the ore is broken along the planes of banding, and the roasted charge is obtained largely in the form of small tabular pieces.

Separation by Friability.—A practical method for effecting the separation of some minerals through their different degrees of friability has been devised by Fr. Buttgenbach, at the Lintorf lead mines in Rhenish Prussia.[1] The process is there applied to the separation of blende and pyrites. The worthless jig concentrates of these minerals are passed through a Vapart centrifugal disintegrator[2] in which the ore particles, impelled by centrifugal force, are hurled against the circular walls of the machine and then drop through a discharging chute into an ordinary sizing trommel. The speed of the apparatus—about 350 revolutions per minute—is regulated by experiment so as to develop a velocity in the movement of the particles sufficient, upon impact, to break up the blende, but not the pyrites. The fine broken blende is separated by sizing from the coarser pyrites, and an intermediate product—blende and pyrites of medium fineness—is generally formed and returned to the disintegrator. This machine breaks up 2½–3 tons of stuff per hour. The blende sand carries 50 per cent. of zinc,

[1] *Vide*, the QUARTERLY, Vol. III., p. 55.

[2] The Vapart Centrifugal Disintegrator, invented at Vielle Montagne: Illustrated description, *Revue Universelle*, 1881, Tome X., p. 552.

and is a valuable product, which is also true of the pyrites. At Lintorf it is found that for satisfactory working, the material must be coarser than 2.5–3 mm. ($\frac{1}{8}$ inch) and the best results are obtained with 5–6 mm. ore. In developing the process, it will doubtless be found advantageous to run for a comparatively large intermediate product which will then be passed through a second machine revolving at a higher velocity than the first. There are many ores to which this method might probably be well applied, and further accounts concerning it will certainly be awaited with interest.[1]

Electro-Magnetic Separation.—By careful roasting at a dull red heat (600°), pyrites can be converted into magnetic oxide of iron, which is readily extracted with the magnet from a silicious or calcareous gangue. About twenty-five years ago attention was directed to this means of concentrating pyritiferous ores, and a practice of magnetic separation was developed for very low grade ores of copper and iron pyrites in Northern Italy. An allied practice is still found in operation in the Lill dressing works at Przibram, Bohemia, where spathic iron is separated from zinc blende by gentle roasting (which converts ferric carbonate into a magnetic oxide), and subsequent extraction of the iron with magnets.

The early magnetic separator consisted of a row of fixed horseshoe magnets, beneath whose poles was passed a layer of ore thinly spread upon a traveling belt; or, more frequently, the magnets themselves were movable, being set radially in a horizontal, rotating drum, with their poles projecting from its circumference. In the course of one rotation of the drum either the poles were passed through the pulverized and, if need be, roasted ore, or the latter was fed slowly down upon the cylindrical revolving surface. In either case the attracted particles, being held by the magnets, were raised to a point where they could be conveniently brushed away from the poles and allowed to fall into special receivers.

The objection urged against one and all of these machines was their small capacity—they could treat only a few hundred weight of ore per day—and this drawback prevented their

[1] An example, in Western practice, of a concentration based upon friability, is found in the method pursued at Lake City, Colorado. The ore after being crushed between soft steel rolls is sifted, whereby the friable, finely comminuted, rich mineral is directly separated from the tougher and coarser quartz. *Vide*, the QUARTERLY, Vol. IV., p. 3.

general adoption. It was not until large electro-magnetic separators were constructed by French and German inventors that experienced ore-dressers found it practicable to introduce magnetic concentration in their works. Of late years several excellent magnetic plants have been erected.

One form of separator devised by Dr. Werner Siemens, for a mining company working an ore of oxidized zinc and spathic iron in Spain,[1] has the form of a rotating trommel, or drum, set on a slightly inclined axis. The drum consists of a number of annular iron discs, separated from one another by rings of brass. The discs are held firmly in position by iron strips, which bind them together on their outer peripheries, and so serve to convert them into a series of horse-shoe magnets whose poles form the inner surface of the drum. The end-discs of the drum are secured to iron frames or spiders, which support the whole on an insulated steel axle. The magnetization of the apparatus is effected by passing a current through a circuit of wire, which is wound around the brass rings, between the annular discs. Pulverized ore is charged, after roasting if necessary, into the inclined drum, and slides gradually toward the discharge end. The magnetic particles adhere to the sides of the drum and are raised above the axle to a line where a fixed brass scraper detaches them. They fall into a small brass leader set around the axle, and are discharged by a brass screw conveyor. A refinement is introduced into the apparatus by surrounding the rings at the head of the drum with fewer coils of wire than those at the discharge end. This end, therefore, becomes the most strongly magnetized, and picks out of the ore such feebly magnetic particles as pass through the head of the drum without being removed. Such arrangement distributes the work of separation between all the rings of the drum and notably increases the capacity of the apparatus. Small machines, 3½ feet long, 2½ feet in diameter, are claimed to treat 1–2 tons of ore per hour, according to the ease or difficulty of the separation.

An interesting magnetic plant is in operation at the Friederichssegen Mine near Oberlahnstein, Nassau, treating roasted jig products of blende and spathic iron. Ore up to 5 mm. (⅛ inch, or nearly 3½ mesh) goes through the process, but the size best suited for it is found to be that of 3 mm.

[1] Illustrated description: Werner Siemens, *Gesammelte Abhandlungen*, 1881, pp. 537, *et seq.* (Julius Springer, Berlin).

(¼ inch, or 6 mesh). Roasting is performed in a long Freiberg roaster and in two short reverberatory furnaces. The latter give the most satisfaction; two men running the two smaller roasters for twenty-four hours can put through as much ore as six men at the long one, for in the small furnaces there is no periodical movement of the charge along the hearth, while the efficiency of the roasting very nearly equals that reached in the large one. The roasting in the small furnaces lasts two hours, during which time the escape of carbon dioxide for the ore is noticed by the sound of slight crepitation. At end of the operation the charge is at a dull red heat, and is tested with a hand magnet. The roasted ore is elevated to bins, which supply the magnetic separators. There are four of these machines—two on one floor of the mill and two on the floor below. The upper machines receive equal quantities of ore, and both produce an enriched zinc concentrate and an enriched iron concentrate. Each of these products is fed through chutes to a separate machine below, and these yield the final products—marketable zinc and iron concentrates. The whole plant treats 25 tons of ore per day (but could probably be worked to a larger capacity). The stuff before roasting carries 8–9 per cent. of zinc, 20 per cent. of iron, and the balance as combined sulphur and gangue. After the two separations the iron concentrate runs 3–5 per cent. of zinc, and the zinc concentrate carries 8–9 per cent. of iron and 36–44 per cent. of zinc.

The separator consists of a copper drum, about 2′ 6″ long, and of the same diameter; it is mounted on an insulated, horizontal axle and has a slow revolving motion. Within the drum, and occupying the sector of a quadrant, there are several long stationary electro-magnets, connected by insulated wire with a Gramme dynamo. The roasted ore moves in a thin layer down an inclined chute and strikes the cylindrical surface of the drum within the limits of the magnetic field, and where the surface is moving upward. The non-magnetic ore falls at once into a receiver, but the magnetic particles adhere and are carried over the crown of the drum; after passing beyond the magnetic field they drop into a separate receiver. The whole apparatus is enveloped by a hood, and all the dust is drawn from it by an exhaust fan. The process seems to work smoothly and give satisfaction.

A number of other electro-magnetic separators have been

brought to public notice,[1] yet with the small experience thus far gained, it would be surprising if there did not still remain much room for improvement. An active competitor with certain magnetic concentrations is sure to be encountered in the steadily-spreading wet processes for the metallurgical treatment of low grade copper ores.[2]

Features of Mill Construction.—In no mill or factory does smooth and regular running depend more upon small, apparently unimportant, mechanical parts, than in an ore-dressing establishment. Continuous automatic mechanism necessitates in very first instance the use of the soundest material and best workmanship, not only for the separating machines themselves, but for all the accessories, the shafting, belting, elevators, conveyors, etc. The mill structure, also, particularly if designed with several floors or stories, must be of very substantial construction to withstand the continual vibrations produced by crushers and jigs. Several cases could be cited of mills which, though excellent in general arrangement, have proved comparative failures, solely because in all their parts they were of too light a design. The newer mills comport in details of shafting, setting, replacing of wearing parts, etc., with present views of durability and economy; many of the clumsy and at once weak and inefficient mechanical designs and mill plants, familiar to the readers of Gaetschmann and Rittinger, have all but dropped out of sight in the steady march of improvement. The recent introduction of iron framing for sets of sizing trommels[3] and the construction of iron battery frames, though approved by engineers of eminence, will hardly meet, at present, with a general indorsement. For stamp batteries in particular, the continual succession of shocks will inevitably loosen rivets and joints, without there being a satisfactory way of tightening them up. The increased cost of iron construction and the deterioration by rust are other points brought to bear against it.

[1] See, for example, the description of Vavin's Separator, which is said to extract 2 tons per day of magnetic sands or scales from their admixture with other bodies. *Revue Universelle*, 1881. Also the description of Edison's Separator, which appeared in the technical journals in 1880.

[2] As index to the path which investigation has been pursuing on this subject in America, the reader is referred to the article of Messrs. Eustis and Howe, "Contributions to the Metallurgy of Nickel and Copper." Trans. Am. Inst. of Mining Engineers, 1881–82, Vol. X., p. 305.

[3] By the Humboldt Machine Shops at Kalk, near Cologne.

In localities where the mills are run solely by wheels or turbines, the variability in the water supply sometimes throws a portion of the mill into idleness. To prevent, at such times, any interruption of mining operations, some dressing works are furnished with large storage bins which are fitted with chutes or automatic feeders allowing ore to be gradually drawn from them into the mill at a very small expense of labor. Many of the works, however, have permanent or auxiliary steam engines, and quite a number of these are of most approved patterns, and of high efficiency.

An excellent practice prevails of lining with sheet iron all launders but those conveying feed water. One or two mills have iron launders, but these are not to be generally recommended. Before setting a new plant in operation, all the separators, conduits, etc., are thoroughly soaked, to swell and tighten the joints, by allowing clear water to flow through them for fully three weeks. Work is then begun, and is characterized throughout by careful, intelligent supervision and economic management.

ERRATA IN VOL. V., NO. 1.

Page 10, 3d line from bottom.—For "1.5 m. down to about 0.5 m." read "1.5 mm. down to about 0.5 mm."

Page 57, 11th line from top.—For "2 FeO, 2 SiO_2," read "2 FeO, SiO_2."

Page 58, 7th line from top.—For "4 (2 CaO, 2 SiO_2) + (Al_2 O_3, 3 SiO_2)," read "4 (2 CaO, SiO_2) + (2 Al_2 O_3, 3 SiO_2)."

PROFESSIONAL NOTES.

Civil Engineering.

The Arlberg Tunnel.—The tunnel through a portion of the Alps at Arlberg in the west of the Tyrol is practically completed, the headings having met in November.

The work affords another example of the effectiveness of power-drills and high explosives.

The total length of the heading is 33,660 feet, of which 32,251 were driven in exactly three years, or at the rate of 29.5 feet per day.

The Mont Cenis tunnel required 2.6 times and the St. Gothard twice this time.—*Eng. and Min. Journal, Vol.* 36, *p.* 379. S. S. F.

Mining Engineering.

The Poetsch method of Sinking through Quicksand by freezing was noted in the last number of the Quarterly.

Since that issue several engineers of prominence have witnessed the actual working of the plan at Schneidlingen, Germany, where a shaft has been sunk through four metres of quicksand to the lignite beds.

Mr. Geo. C. André says in the *Colliery Guardian*: "The evidence there obtained on the spot is sufficient to remove all doubts on certain points, and goes far to show that a very important addition has been made to the art of mining." * * *

Enough has been accomplished to place the practicability of the system beyond a doubt. It is yet too early to compare the cost with that of the ordinary methods, but it is easy to see that where there is much water to be dealt with, Poetsch's system must be an economical one; it certainly affords a high degree of safety in working. S. S. F.

Mechanical Engineering.

A Device for Getting Marine Engines Off Center has been successfully employed on steamers on the Great Lakes.

A supplementary steam cylinder placed near the main shaft drives a block of metal or segment of a circle fitted with V friction grooves corresponding to similar projections on the face of a wheel or drum keyed to the shaft. The valves controlling the admission of steam to this starting cylinder are connected with handles in the engine-room so that the engineer, without leaving his post or giving an order, can throw his engine "off center."

The necessity for such a device is increased in lake navigation by the cramped and crowded harbors. Moreover, the shallow water in the rivers necessitates boats of light draught and consequently of little lon-

gitudinal stiffness. This lack of stiffness makes it of prime importance that the engines should give as little oscillation as possible, and in the steamers with double engines the cranks are put at 180° instead of 90° as is usual in salt-water practice. The double engines are consequently as liable to "dead centers" as the single engines.—*Transactions Am. Soc. Mechan. Eng. Vol. IV.* 1883. D. E. M.

A Self-Registering Ship's Compass, devised by Robert Pickwell, C.E., employs sensitized paper to register the direction of the ship's course, and also the exact moment when any change of course takes place. Clockwork placed in a cylindrical barrel causes the barrel to revolve once in 24 hours. This cylinder is covered with sensitized paper, which is protected from the light by a second hollow cylinder placed concentric with the first and completely enveloping it save for two fine slits which are cut through the brass shell along an element of the cylinder, consequently parallel to the axis and running across the strips of sensitized paper.

These concentric cylinders are mounted under the card of the ship's compass, which is as usual mounted on steel points with agate bearings. The card, however, differs from the usual type, in having a curved slot, cut so as to intersect the straight slots in the hollow cylinder in a point, which point varies in position according to the direction in which the ship is headed. Part of the light thrown on the surface of the card passes through the slots in the card and cylinder and registers on the sensitive paper below. After development of the image, a wavy line appears which is the locus of the points of intersection of the two slits.

The diagram is divided by vertical lines representing time, and by horizontal lines representing direction.—*London Engineering, Oct.* 26, 1883. D. E. M.

The Athabaska, a Steel Steamer built on the Clyde for the Canadian Pacific Railway, and intended for service on the Great Lakes, was built in two sections so as to permit of its being transported through the shallow channels of the Lower St. Lawrence. On her arrival at Montreal, the two sections were placed on pontoons and the passage of the canal was easily accomplished. The Athabaska is 270 feet over all, 38 foot beam, draws 16 feet 2 inches, and has a carrying capacity of about 2,000 tons. She is entirely of steel, and has seven water-tight compartments.—*Iron Age, Dec.* 6, 1883. D. E. M.

Another Possible Cause of Boiler Explosions.—M. Vignes, in the *Journal de la France,* draws attention to experiments made in 1846 to show the influence which air exercises on the boiling point of water. Ordinary water is placed in a clean glass tube, open at one end, and boiled until all air above the surface of the water and that dissolved in the water is driven off. Then, when the upper part of the tube is full of pure steam, the mouth is hermetically sealed. When cool, the tube is half full of water only, above which is vapor of water at a very low pressure. Now the lower end of the tube is plunged into a bath of oil or glycerine, which is gradually heated. No ebullition is visible in the tube when the temperature reaches 234 degrees Fahr. At 240 degrees Fahr., however, the column of water bursts, as it were, in two, with a

sudden explosion, and part of it is flung with such force against the sealed end as often to break it open. Now, in industrial works, it often happens that a boiler, having been filled with water, works for three or four hours without receiving a further supply. It may then be cooled down, and the next time it is wanted it may probably be fired up again without starting the feed-pump, the water level being judged sufficiently high; however, this water will be in the same condition as that in the test tube—that is, will be deprived of all air—and consists of water below and vapor above; the latter, however, being probably at a much higher pressure than that of the water in the tube. This water has no free surfaces in its interior due to the presence of bubbles of air, from which evaporation can take place. Consequently, as in the test tube, there will be delay in vaporizing, at least, until the expansion becomes great enough to overcome the pressure of the superincumbent vapor, and a sudden flashing into steam, which will be of the nature of an explosion, and may easily overcome the resistance of the boilers. In the test tube, the pressure of the temperature of explosion—240 degrees Fahr.—will be eighty-six times what may be taken as the pressure of the superincumbent vapor in the boiler. That pressure will probably be much higher, and the pressure of the explosion will probably be much higher also. To avoid this source of danger always feed a boiler when it is fired up after standing. This will lower the pressure and facilitate evaporation by distributing the mass of water in the boiler, and charging it to some extent with bubbles of air.—*Eng. and Min. Journal, Dec.* 29, 1883. W. F. M.

METALLURGY.

Petroleum as a Fuel in Iron Manufacture and Metallurgy.—The Vapor Fuel Company gives details of the apparatus used to utilize petroleum as a fuel for heating and puddling furnaces.

The generator of "vapor-fuel" is termed the "thermogen," and consists of two retorts of the best cast-steel, tightly elbowed together at the top. Within the inner retort are two globes, also of cast-steel, while surrounding the whole and resting upon a base of brick-work is the apparatus complete.

The crude petroleum is kept in tanks underground situated at some convenient point outside of the works.

To produce the "vapor fuel," steam is forced between the two retorts, is superheated, and thence passes into the lower globe within the inner retort and then into the upper, heating them both intensely. A small force pump connected with the "thermogen" forces the oil through a small pipe, entering above the upper globe, upon the surface of which it falls in a fine spray. This globe is generally so intensely heated by the steam that has passed through it as to vaporize the oil instantly. Then the steam, which has passed out of the "thermogen" through a pipe extending from its top around on the outside to its base, re-enters, and, mingling directly with the gas, acts as a carrier, taking it through a pipe from the top of the retorts to the furnace. "Vapor-fuel" is used at the Norway Iron Works for boiler heating, for puddling, steel-making and reheating furnaces, and has been found entirely satisfactory. It is easily regulated, and under control it affords a high heat at a moment's notice, gives off no dangerous or disagreeable gases, and there are no ashes or débris to be removed where it is used.

One man can operate a "thermogen" with ease, acting as engineer and fireman, and start a flame that has a heat of 6,000 degrees Fahr. in one minute, and yet with the turning of a valve can extinguish it entirely or reduce it to the extent that the exigencies of any operation may demand.

The use of "vapor-fuel" for the heating of steel ingots and blooms and similar works is said to be satisfactory. When applied to steel-melting, however, its merits are said to be still more conspicuous, no expensive alterations of a coal-gas furnace or the introduction of "vapor-fuel" being necessary. The cost of a "vapor-fuel" plant doing the same work as a coal-gas plant is said to be one-tenth that of the latter, while it also insures a great saving in labor.—*Eng. and Min. Journal, Dec.* 29, 1883.

W. F. M.

Ingot Molds.—A new ingot mold has been devised in England. It has an outer casing of metal, an inner shell of refractory material, with a space between them filled with non-conducting material. The casing is of cast or rolled metal, and open top and bottom. Bars of metal projecting inside are riveted to the lower edges; on these stands the inner shell. To the upper edges are attached loop rings to lift the molds. The inner shell of the form of the ingots required is of magnesian limestone, fire bricks and coke, heated, made fine and mixed with mineral oil to a paste, forced into a metal mold of the form required, then dried and heated. Around the shell are bands of thin metal which expand and contract with the shells, and admit of their being removed. The shell is put inside the casing and the space filled with porous nonconducting material, the shell being washed inside with ground plumbago and water is filled with the metal. It remains to be determined whether this method will be successful. T. E.

Improvements in the Bessemer Process.—Capt. Wm. R. Jones has patented a method of treating metal in the Bessemer converter when it is too hot. Formerly scrap metal was added till the heat was reduced. By Mr. Jones' patent steam is introduced into the molten metal with the air blast. The time during which steam should be admitted depends on the size of the steam pipe, the nature of the metal, pressure of air blasts, etc. In working a 10-ton converter with steam at 50 lbs. pressure through a 1½-inch pipe, it may be forced with the air six minutes, or from a third to half the length of the blow. Steam may be introduced just before the completion of the blow, or at any time when the metal is too hot. It may be used continuously, also, if needed. A fine spray of water may be used instead of steam, but the latter is preferable. Mr. Jones claims that a pig metal high enough in silicon to avoid the presence of too much sulphur may be used with this invention.

T. E.

In the Substitution of Steel for Iron which is demanded by almost all the industries of the present day, ingot iron should be used in places where strain will be required.

Most persons who say "mild steel" mean by that ingot iron. There is, however, a very great difference between the two materials; and where shafting is to be made and is likely to become hot occasionally, under such conditions that it must be cooled with water, care must be

taken that no substance which will harden shall be used, and ingot iron should be the material used, the carbon being determined by an actual experiment. For when these shafts become hot it is necessary that they should be cooled ; and if the amount of carbon is high, microscopic cracks are produced on the surface which eventually propagate themselves to the interior, and breakage is the result, which is always unexpected.

Latterly mild steel shaftings have been replaced in a large number of works in Germany ; but these have broken so often that they are being rapidly replaced by hammered weld-iron.

There is another reason besides tempering which causes these shafts to break—that is, blow-holes caused by the gases given off from the steel. In one shaft 15 inches in diameter a hole as large as the fist was found, in which were two small steel balls which had ground themselves quite round and smooth in the course of two or three years before it broke.

Many shafts have broken under a strain nowhere near what should have been the limit of the material, and these breakages have been found to be due either to cavities in the interior caused by the boiling of the steel, or to the formation of microscopic cracks.

It has been found also that in some cases steel boilers have cracked clear across the bottom of the boiler owing to the same cause.

No material capable of hardening should be called iron, but steel ; much of the so-called iron is really steel. It must be remembered that blow-holes are never either hammered or rolled out, but are simply flattened, and when they come to the surface form the commencement of a crack.—*Eng. and Min. Journal, Vol.* 36, *p.* 16. T. E.

Manufacture of Sheet Steel.—It seems likely that in the very near future steel will be used altogether in the place of iron, and in a great many cases in the place of cast-iron.

This steel may be as low as $\frac{1}{10}$ per cent. of carbon, which is extremely soft, or a much higher percentage may be made equally well.

In the year 1882, 73 steamers with a total tonnage of 143,000, and in the same year 116 vessels with a tonnage of 216,784, were built, and there are at the present time six times as many boilers made out of sheet steel as of sheet iron.

There is a great difference of opinion as to how this steel should be made, many works holding that steel to be uniform must be made from crucibles, and others that it may be made in an open hearth.

The great difficulty in getting large pieces of steel is the danger of blow-holes, and in order to overcome this, ferro-silicon was formerly used, the silicon uniting with the oxide of iron to form a silicate which may or may not be fusible with difficulty. The danger is always that some of it will remain and form a brittle slag, so that recently ferro-manganese-silicon has been used, the object of the manganese being to make the slag fusible, while the silicon is easily oxidized by the oxygen of the iron.

The difficulty in making castings is to have them dense, free from holes and entirely devoid of scab or scales on the outside, so that they may go to use at once without finishing.

In order to do this it is necessary to have the mold of peculiar construction.

The temperature required in order to have the metal quite fluid causes

very large contractions in the metal; and this requires that the mold should be made with great judgment, sufficiently compact to hold the steel, but sufficiently fragile to yield under contraction.

Many experiments have been made in this country and in England; but only two have been successful, for the temperature of the steel is so high that it is difficult to find a material that can be used for the face of the molds refractory enough to avoid the chemical action of the metal.

Repee in England patented a method of using old crucibles which were ground and mixed with 20 per cent. of graphite, and then shaped and baked in a furnace, coated with coal tar, and while still hot from the baking the steel poured into them. The difficulty with this process is that it is almost impossible to make soft steel in them, as when the liquid steel comes in contact with the carbonaceous material it absorbs carbon and becomes harder. Though smoother than ordinary castings, they require a considerable amount of treatment, and must be annealed before use.

Mr. Cowing, of Cleveland, in order to overcome these objections, has patented a process which consists of using the purest quartz or quartz sand, which he calcines in a furnace and then grinds to an impalpable powder, adding sufficient glue water to the molds to make them stand up. Experiments with these have shown that the steel makes no impression on the material of the mold, and that the castings are smooth and require no finishing. This patent has been used for making heavy castings to take the place of large forgings, and is now in use in about 25 of the steel works of this country.

Whichever way the steel is made or cast, there is a great variety of opinion with regard to what should be done with it afterward.

Some steel makers insist that a careful cooling of the casting so as to lower the temperature very greatly is all that is necessary to insure a complete equilibrium of internal strain, and that any subsequent heating cannot be uniform, as all the thin parts will be heated through more thoroughly than the thicker ones. Others maintain that the cooling that takes place in the mold cannot be so uniformly performed as to have the casting free from molecular strains, which will be greater as the casting is larger and the mold therefore more rigid.

At Terre Noire great importance is attached not only to annealing but also to tempering the castings in oil in order to give them greater ductility. They maintain that castings with variations of form can be made uniform in the sand mold; that this varying rate of cooling between the thick and thin parts causes variations in crystallization, and that the tempering in oil transforms the large grain of the metal into one perfectly homegeneous.

In order to see the results of this, four specimens were taken from the same casting and treated; with the following results:

	TONS PER SQ. IN.	ELONGATION.	LENGTH.
No. 1	32.7	16 per cent.	5 inches.
No. 2	33.7	17 "	"
No. 3	38.6	17 "	"
No. 4	41.1	15 "	"

No. 1.
No. 2 was annealed.
No. 3 was annealed and tempered in oil.
No. 4 was twice tempered in oil.

In very large castings molecular cavities or flaws may be produced in the center, due to the fact that the outer portion cooling first becomes rigid, while the inner is still fluid. The contraction that takes place when this cools, severs the inner from the outer portion and leaves the flaw. In other works, the annealing is done differently; the casting, taken as hot as possible from the mold, is placed in a furnace and kept there for some hours at a high temperature, and then cooled down by gradually withdrawing the fire from the furnace, taking with a large casting a week to pass from the liquid condition to a temperature cool enough to handle. This seems to answer the purpose better than other methods, but it requires a very considerable length of time and consequently an expense of capital to do it.

In some of the largest steel works the steel is never allowed to grow cool, but is always covered with charcoal, when there is to be an interval between its treatment.—*Eng. and Min. Journal, Vol.* 36, *p.* 2.

T. E.

Theory of the Crucible Steel Process.—Prof. Ledebur, of Freiburg, says that the manufacture of crucible steel has been neglected. Mr. M. M. Troost and Hautefeuille have shown that silicon is reduced by carbon from crucibles containing silicic acid, and conveyed to the iron. Silicon prevents iron from secreting gases in solidifying, but we do not yet know how far external conditions affect the silicon in the crucible. As carbon is the reducing agent for silicon, carbon crucibles will reduce more than those of other material; this theory has been proved by experiment. The duration of the melting process and the melting temperature must also effect the quantity of silicon. Manganese in iron may help to reduce the silicon, if the protoxide of manganese is allowed to become saturated with silicic acid, and the heat is great. If spiegeleisen is melted in a cupola, with a lining containing silicic acid it absorbs silicon, eliminating manganese, and is changed into gray pig-iron. In melting cast steel in the crucible it will be richer in silicon the richer the charge is made in manganese. This has been settled beyond doubt by a series of careful experiments; and it was also shown that the close affinity of the manganese remaining in the steel itself promoted the reduction of the silicon through the carbon of the crucible. A closer affinity exists between carbon and manganese than between carbon and iron. While in melting steel poor in manganese a slight decrease of carbon is perceptible, manganiferous steel shows a large increase of it caused by absorption from the crucible containing it.—*Eng. and Min. Journal, Dec.* 15, 1883, *p.* 367. T. E.

Iron High in Titanium.—An iron sand native in New Zealand has been analyzed and found to contain 60 per cent. of iron and 15 per cent. of titanic acid. Unsuccessful attempts have been made to smelt it unmixed with other iron ore. A recent patent suggests that the sand be allowed to trickle over a stream of molten iron, or places a vessel containing the sand above the output, regulating its flow by a tap which varies as the size of the stream of iron varies. The iron and sand are mixed by allowing the metal to fall into a shallow vessel; it is sometimes stirred. The pig metal so prepared may be submitted to the puddler, stamper, roller, etc., and turned out in various forms of iron or steel. A superior class of castings is produced. Small metal founders will be able to produce at a cheaper rate a perfectly homogeneous

material of any hardness or quality for machine bearings, etc. Several New Zealand firms are using this patent. T. E.

Utilization of Phosphoric Slags.—A new method of utilizing phosphoric slags is to dissolve the powdered and roasted slag in muriatic acid, so diluted that most of the silica with the phosphates of lime and magnesia will be dissolved, and will remain so, not separating in a gelatinous state. These solutions contain iron and manganese. When neutralized by lime or magnesia, the precipitates will be phosphates of lime, magnesia and iron together with phosphate of manganese and silica. By fractional precipitation, however, the phosphates of iron and manganese, the earth-basic phosphates and silica may be obtained separately. By adding a limited quantity of lime or magnesia, the phosphates of iron and manganese are precipitated; by a further addition the phosphates of lime and magnesia are separated, and by a still further addition, silica. The phosphates of iron and manganese are mixed with lime or magnesia and roasted. The phosphates of lime and magnesia formed are then extracted, as the earth-basic phosphates in the slag are, the residue consisting mainly of oxides of iron and manganese.

T. E.

Consumption of Fuel in Blast Furnaces.—An ordinary blast furnace consumes 50 tons of coal a day. Each ton of coal gives 130,000 cubic feet of waste gases, which leave the furnace at about 500° F. This gas weighs altogether 4 tons.—*London Engineering, Vol.* 35, *p.* 230.

T. E.

Concentrating Nickel Mattes.—Besides his work in developing the method of Bessemerizing copper mattes, M. Manhès has been experimenting on the concentration of nickel mattes. So far as they go, the results are encouraging. They show that it is not difficult to concentrate low grades nickel mattes so that the product can be refined directly. But it remains to be seen how arsenic behaves in the converter. The mattes experimented on seem to have contained little. If it obstinately clings to the metal, the advantages of cheap concentration would be overbalanced by the great quantity in later operations. There is, however, great satisfaction in the promise held out of the cheapening of so useful a metal as nickel, especially since it is part of an alloy used by a Pittsburgh firm as a protective coating for iron and steel.—*Eng. and Min. Journal, Dec.* 29, 1883, *p.* 393. T. E.

Extracting Cobalt and Manganese from their Ores.—A new process for this purpose has been patented in England, which uses sulphate of iron to extract oxides of these metals from their ores as sulphates from which they are easily converted into oxides.

The ore is crushed fine, mixed with water to a paste, and the per cent. of oxides of cobalt and manganese ascertained. Enough sulphate of iron is added to convert the oxides into sulphates. It is boiled half an hour, the solution decanted, the sulphate washed from the residue, and the solutions treated to reconvert the sulphates into oxides. If the slime is put in cold water for twenty-four hours the oxides will be converted into sulphates, but the boiling is less tedious. The sulphate of iron may instead be mixed with the dry crushed ore and heated in a

furnace till the sulphates are formed. These may then be washed with cold water and precipitated as oxides as before. T. E.

Bessemerizing Copper Mattes.—Great difficulty has been experienced in Bessemerizing mattes containing 30 per cent. of copper, owing to the violent ebullition produced by blowing in air. M. Manhès made some experiments on these mattes at his works at Védènes. He saw that the main difficulty was produced by the cooling action of the blast, and substituted horizontal for vertical tuyères, forcing the blast, into the bath at a point above the bottom of the converter, so that the copper did not chill. As fast as produced, it sank below the level of the blast and remained liquid. Thus all the matte was desulphurized, and the copper contained but 1½ per cent. of foreign matter.

To overcome the difficulties caused by cinder with poor mattes, quartz was added to diminish the corrosion of the walls; and manganiferous pig-iron to give greater fluidity to the cinder. The trials at Védènes proved that it is easy to convert copper mattes into blister copper containing not more than 1½ per cent. of impurities. The manufacture would be simpler if the works could procure mattes of uniform quality. The elimination of arsenic and antimony is an important point; treated by M. Manhès' process they disappear. The product contains—copper, 98.07; sulphur, .09; iron, .05. Treating copper by the Bessemer process will cost only one-third as much as by the old process, though it is not claimed that it will modify the metallurgy of copper so radically as that of iron and steel. The amount of fuel and labor is greatly reduced, and many ores can be worked by it that have heretofore been unavailable.—*Eng. and Min. Journal, Dec.* 1, 1883. *p.* 337. T. E.

On Dust Chambers.—C. A. STETEFELDT. The author refers to a paper read by Prof. Egleston on the collection of flue-dust at Ems, in which he described some successful experiments carried out by Mr. Freudenburg, and said, "These experiments have demonstrated the importance of surface over volume" in collecting a settling dust.

Mr. Stetefeldt admits that the Ems construction of suspending a large number of sheets in a flue to create a maximum of surface is new and original, but claims that the principle involved has been demonstrated in dust chambers constructed for his furnaces several years ago (1873).

He says, that in erecting the first Stetefeldt furnaces, he followed the old notion that by lessening the speed of the current, the fine particles would settle. He soon discovered that the amount of dust collected in the large chambers was very slight compared with their volume, and that more dust settled in contracted places, and wherever the current was forced to move around a sharp corner and strike a wall.

He then abandoned large chambers and adopted the following, which is in the Ontario Mill, Utah.

Each chamber is divided by an apron into two parts, and the openings connecting two chambers on alternate sides of the partition walls commence a considerable distance above the floor, so that the current has to change its direction several times in passing from chamber to chamber, while the dust collected at the bottom remains undisturbed and can accumulate in considerable quantities before discharging be-

comes necessary. He mentions the fact that dust which has been chloridized settles much easier than dust which has been roasted merely, because red-hot ore roasted with salt is sticky and clings whenever it is thrown by the current of gases against a solid surface. What is effected at Ems by a maximum of surface, he effects by frequent changes in the direction of the current. Whenever dust and fumes from smelting-works are to be collected, the Ems construction is the best, but for dust chambers close to a roasting furnace, which produces a very large quantity of dust, his construction he considers preferable on account of working facilities.—*Eng. and Min. Journal, Vol.* 36, No. 4. W. F. M.

Electricity.

The Daft Electro-Motor for propelling railroad cars was tried at Saratoga, N. Y., on Nov. 24. The current which operates the motor is conducted by a central rail instead of by an overhead wire as in Berlin by the Siemens method. The current in the central rail was of so low tension as to produce no serious results when animals came in contact with it.

The actual performance consisted in the hauling by a two-ton motor of a five-ton car, loaded, more than a mile with a rise of 70 feet. The apparatus worked easily and the experiment was regarded as a practical success.—*Eng. and Min. Journal, Vol.* 36, *p.* 356. S. S. F.

Telpherage is a term used to express the "transmission of vehicles by electricity to a distance, independently of any control exercised from the vehicle."

Profs. Jenkin, Ayrton and Perry have evolved a new method of accomplishing this result. The vehicles (a series of buckets and a motor) are suspended from the elevated rail, which likewise serves to conduct the current. The rail is composed of sections 120 feet long, the alternate ones being connected. One set of sections is connected with the generator—the other set with the ground. The train is of the same length as the sections, the front and hind wheels being in electrical communication through the motor, the intermediate wheels being insulated. The train thus, in every position, except when exactly over points of junction, connects the two conductors and is propelled by the current.

The practical tests have only been made on a short line, and no details of cost and power used are given.—*Van Nostrand's Eng. Mag. Vol.* 29, *p.* 508. J. B. M.

Chemistry.

Boracic Acid and Hematine as Reagents in Alkalimetry.—Boracic acid can be obtained of exactly normal strength by dissolving boric anhydride (vitrified boracic acid) in water. The color reaction is furnished by hæmatoxylin or hematine, the coloring matter of logwood. The hematine solution is freshly prepared every day by dissolving a little in some distilled water. With acids both strong and feeble, the solution has a pure yellow tint, which, by the addition of the least excess of alkali, changes abruptly to purple. With ammonia, or when ammoniacal salts are present, the color obtained is violet. This last reaction is a a very delicate qualitative test for ammonia.—*A. Guyard, Bull. de la Soc. Chem.*, 1883, *p.* 422. J. B. M.

Preparation of Nitro-Molybdic Acid in a State of Maximum Concentration.—The author prepares a concentrated solution of Ammonium Molybdate, and adds it drop by drop to a mixture of equal parts nitric acid and water, constantly stirring, until a slight milkiness is produced; a drop of nitric acid being now added renders the solution perfectly clear. After cooling, this solution may be heated from 70° to 100° C. without precipitating molybdic acid, while if the temperature be slightly raised during the preparation, almost all the molybic acid may be separated. On this account it is advisable to operate on small quantities at a time.—*A. Guyard, Bull. de la Soc. Chem.*, 1883, *p.* 423. J. B. M.

Rœssler's Method of Manufacturing Sulphuric Acid and Sulphate of Copper.—Sulphurous acid and air are passed together into a boiling solution of cupric sulphate by a steam injector. The reactions occurring may be expressed by the formulæ $2\,Cu\,SO_4 + SO_2 + 2\,H_2O = Cu_2\,SO_4 + 2\,H_2SO_4$ and $Cu_2SO_4 + 2\,H_2SO_4 + O = 2\,Cu\,SO_4 + H_2\,SO_4 + H_2\,O$. These reactions occur simultaneously.

For the manufacture of sulphate of copper the converter is filled with scrap copper and water. The sulphurous acid containing some sulphuric acid is then injected, the copper is attacked, forming sulphate, which when sufficiently concentrated, is drawn off and crystalized.—*A. F. Wendt, Transactions Am. Inst M. E., Troy,* 1883. J. B. M.

The Purification of Ammonium Fluoride.—The ammonium fluoride and hydrofluoric acid met with in commerce almost invariably leave a residue when volatilized, which interferes with their use in the estimation of silica, and in the decomposition of silicates. The purification is conducted in the following manner:—The ammonium fluoride is dissolved in the least possible amount of water, and a slight excess of ammonia added. The solution is now filtered into the crucible containing the silica, concentrated if necessary, acidified with sulphuric acid, evaporated to dryness, and ignited. Hydrofluoric acid is treated in the same manner. Of course platinum vessels are employed in these operations.

The authors prefer to use hydrofluoric acid, as it furnishes a more concentrated solution, besides being much cheaper.—*P. T. Austen and F. A. Wilber, in Am. Chem. Jour. Vol.* 5. J. B. M.

In order to arrive at the same end I have been in the habit of employing two crucibles—one inside the other. The substance analyzed is in the inner one; the ammonium fluoride and sulphuric acid in the outer. The inner crucible is raised about ⅛ inch above the bottom of the outer by a small stage of platinum foil. The cover of the larger crucible being then put on, the arrangement is allowed to stand some time at a gentle heat till the silica is volatilized. This plan works very satisfactorily, and in some respects is to be preferred to the usual one.

J. B. Mackintosh.

Estimation of Sulphur in Pyrites.—Half a gram of pyrites is treated in a glass-stoppered vessel of about 100 c.c. capacity, with 30 c.c. water and about 4 c.c. bromine. The stopper is quickly inserted, and the vessel shaken for five minutes. When the oxidation is ended, which is known by the disappearance of all pulverulent sulphur adhering to the sides of the glass, the solution is emptied into a casserole and

the majority of the bromine allowed to evaporate in the cold. The solution is almost neutralized with ammonia, and then poured into an excess of hot ammonia contained in a platinum dish, and digested at a gentle heat from 10 to 15 minutes. The sulphuric acid is determined in the filtrate from this as usual.

The total quantity of bromine employed must be added at once, as otherwise there may be a loss of sulphur in the form of sulphuretted hydrogen. Some iron volatilizes as bromide with the excess of bromine, so that it cannot be determined in the precipitate by ammonia.—*C. Bodewig, Zeit. für Anal. Chemie.*, 22, *p.* 577. J. B. M.

Test for Tin.—A solution of .100 gram brucia in 1 c.c. nitric acid is diluted to 50 c.c., and boiled. On cooling, it is ready for use. If a drop of a solution of stannous chloride be added to a few drops of the reagent, a purple color is produced. Organic matter, chloride of zinc, or nascent hydrogen do not interfere with the reaction. Ammonium sulphide and sodium hyposulphite produce a similar coloration.—*Chas. R. Dryer, Chem. News, p.* 257. J. B. M.

Volumetric Determination of Iron.—If some sodium salicylate is added to a ferric salt, a purple coloration is produced. If now the solution be titered with standard hyposulphite at a boiling heat, the color will be discharged when the iron is all reduced.—*Chem. News, p.* 248; *from Comptes Rendus.* J. B. M.

Volumetric Determination of Iron.—In estimating iron by potassium bichromate, the solution should be reduced by stannous chloride or a sulphite, since zinc interferes with the final reaction with ferricyanide.—*E. B. Schmidt, Chem. News, p.* 245. J. B. M.

Method for the Analysis of Silicates.—W. Knop fuses 2 grams of the silicate with 10 grams sodium carbonate. The fused mass is treated with cold water till perfectly disintegrated, and then an amount of ammonium chloride equivalent to twice the amount of sodium carbonate taken is added, and the whole is evaporated to dryness on a water bath. The dry mass is now taken up with hot water and filtered. The solution contains chlorides of manganese, calcium and magnesium, and phosphate of manganese. The residue consists of silica and silicates of the sesquioxides.

If phosphate of manganese is present, the filtrate will be turbid when it is diluted with the wash water. The filtrate is concentrated, and the manganese is precipitated by chlorine, taking care to keep the liquid ammoniacal. The precipitate contains manganese peroxide and phosphate; the filtrate, the lime and magnesia.

The precipitate of silica and the sesquioxide silicates is decomposed with hydrochloric acid in a casserole, the ashes of the filter being added, evaporated to dryness, taken up with acid and filtered through the filter containing the manganese precipitate. The solution now contains iron, alumina, phosphoric acid and manganese, which are separated as usual.—*Zeit. für Anal. Chemie.*, 1883, *p.* 558. J. B. M.

MINERALOGY.

Solution for Separating Minerals.—*Wiedermann's Annalen* gives the following method of separating and determining the specific gravity of

associated minerals: The minerals are pulverized and put in a liquid intermediate in specific gravity between them. The liquid is prepared thus: 100 parts of iodide of barium, and 130 parts of red iodide of mercury are well mixed with 20 c.c. of distilled water and heated on an oil bath to 150° to 200° C., until dissolved. Concentrate the liquid until it floats topaz. Permit it to stand several days and decant the clear fluid.

To obtain any particular density, the heavy liquid is mixed with a dilute solution of the same, thus preventing precipitation. S. S. F.

Origin of Gold in Victorian Quartz Reefs.—Mr. Wm. Nicholas, of Melbourne University, says that the laminated quartz reefs are transmuted slate beds. Gold has been found in mine-water, and in incrustations of boilers fed with mine-water; and mine-water must be the source of the gold in quartz reefs. Mr. Newbery, the Australian geologist, thinks that the organic matter in the carbonaceous slate became the precipitant and nucleus for extracting gold from the mineral waters circulating in the reefs. Mr. Nicholas thinks the black slate originally contained gold. To prove this, he made several experiments: No. 1: Metallic gold dissolved, 3 grains; distilled water, two ounces In this a cube of galena and some soft black carbonaceous slate were placed. The next day gold had been precipitated on both substances. After some days quartz appeared on the slate; this may, however, have been in the slate; and other experiments must be made before it can be settled that it was produced in the solution. No. 2: Same solution as No. 1, with 2 oz. mine-water added; bits of hard, black slate from same sample as that placed in No. 1 were put in. In a few days the slate was covered with gold. Two bits of sandstone were then added. Gold also appeared on these. No. 3. Half a drachm of the gold solution, 2 oz. mine-water, a little fine black slate. After four weeks, gold was precipitated on the slate. No. 4: Solution same as No. 2; fine black slate added to the depth of $\frac{1}{4}$ inch. In two weeks a flocculent white substance had formed, and the slate was covered by a brown deposit containing gold. No. 5: Solution same as No. 4: Bits of calcite added. Calcite turned purple, solution remained yellow, light brown deposit on calcite. No. 6: Galena put in same solution turned brown, with dark brown dendritic forms; solution colorless. No. 7: Arsenical pyrites put in same solution, decomposed rapidly, was covered with gold with a few dark dendritic forms; solution nearly colorless. No. 8: Powdered black slate without quartz put in same solution precipitated all the gold; solution colorless. Victorian auriferous laminated quartz reefs are therefore altered auriferous carbonaceous slates, or clayey sandstones, and some of the gold was precipitated from mineral waters. Thus gold and quartz were formed by one operation in nature.—*Eng. and Min. Jour., Dec.* 15, 1883, *p.* 367. T. E.

Astronomy.

The New Equatorial of the Paris Observatory.—Mr. Loewy, the subdirector of the Paris Observatory, has invented an ingenious arrangement for a new form of Equatorial Telescope. The new instrument has just been completed, thanks to the liberality of Mr. Bischoffsheim the Paris banker, who has done so much for the cause of astronomy.

The new telescope is bent at right angles; one part moves in the

plane of the equator while the other part is made parallel to the earth's axis. The second part is fastened so that it can only revolve, and on doing so, carries the former part around in a plane parallel to the equator. At the fixed extremity of the "polar tube" the eye-piece is attached. At the angle between the two tubes a reflecting plane mirror is fixed. Near the outer extremity of the equatorial tube is placed the object glass (which is an ordinary achromatic lens). Beyond the lens is a second mirror. By revolving the telescope and properly inclining the second mirror, any object in the heavens can be brought into the field of view.

The main advantage of the instrument seems to be that the observer can be comfortably housed, and remain in one position while making his observations. The eye-piece end being in the observing-room, the rest of the telescope is out of doors. The disadvantages are that there is loss of light, and changes made in the reflecting surfaces due to temperature or flexure will produce an effect on the image which will be magnified by the whole power of the telescope. Unfortunately, the great Paris reflector constructed some years ago has never proved a success, and this new and ingenious instrument constructed, we think, by the same makers, does not promise to be of any great service. We shall await with interest the authoritative announcements of the test objects the new instrument can make out. For a full account of the new instrument, with a good illustration, the reader is referred to the *Scientific American of Dec.* 15, 1883. J. K. R.

METEOROLOGY.

The Red Skies.—The remarkable atmospheric phenomenon which has recently attended sunrise and sunset, has attracted great attention, not only from the general public, but from scientific men, who have endeavored to give a satisfactory explanation of it. Similar appearances have been noted in former years; but they have been of limited extent, and attributable to local causes. The distinguishing characteristics of the present manifestation are its enormous extent, its persistence, and the fact that the times of its first appearance have varied in different countries, thus suggesting a progressive motion.

In the United States the reports of observers of the Signal Service show that its earliest appearance was in October. At Pensacola, Fla., on the 8th, the phenomenon was observed at both sunrise and sunset. Near the middle of the month it was noted along the southern border from southern California to the Gulf of Mexico. At the close of the month it was observed in great brilliancy in the southern and southwestern States. In the more northern portions of the country, during October, the sunsets were characterized by unusual brilliancy; but the peculiar "afterglow" which marked the later appearances was not noted. In the early part of November the phenomenon was still observed on a few days in the South and West; but after the 20th it appeared in its full beauty over nearly the whole country. In New England, the Atlantic, Gulf, and central States, the lake region, the north-west, and along the Pacific coast, the phenomenon was observed, beginning at various dates after the 21st, according to the weather conditions of the different localities. The 27th was the date in which the appearance was first especially marked in the Eastern States. Since that date, to the end of the year 1883, the skies have been characterized by the same

brilliancy, whenever the weather conditions have been favorable to its observation: the 27th and 28th of December revealing the appearance in the eastern section of the country to a marked degree.

The sky seems to have had essentially the same characteristics wherever the phenomenon has been observed. In Europe and America, however, if we may judge from the published descriptions, the green or blue appearance of the sky has been less noticeable than in India, where the earliest observations were made. In this country the "after-glow" has been ruddy, with at times an orange or greenish tint. The observer at Memphis, Tenn., under date of October 30th, writes, "For more than one hour after sunset there was in the west a segment of red light, whose intensity and brilliancy appeared equal at all points in the segment. The position (altitude?) of the segment was about 30°, azimuth 45° to 120°." On October 31st the appearance was similar, "except that in the north-east quarter of the segment a few converging bands, apparently dark, entered the segment from a clear sky. While no stars were visible in the illuminated part of the segment, they were visible in all other parts of the sky, and also in the bands, which, it appears, were dark in contrast." At Washington, on December 29th, a ruddy arch arose in the early morning, and was about 25° high an hour and ten minutes before sunrise. Soon after, the usual twilight arch appeared, also of a ruddy tint; and the two were seen simultaneously, the former losing its outline, and growing paler as it became tranfused over the sky. During the day, the material causing the appearance was plainly visible as a white haze surrounding the sun to a distance of about 30°. At sunset on the 27th and 28th the phenomena were as at sunrise, but in reverse order, the secondary glow lasting an hour and three-quarters after sunset. While the glow at the end of December is perhaps not as intense in color as when first seen a month earlier, it is the same in other respects. It has been described in profuse detail in the daily press; and several English magazines, notably *Nature*, have devoted much space to it.

Three different hypotheses have been advocated to explain the phenomenon, assigning its cause to aqueous vapor, meteoric and volcanic matter respectively. It is undoubtedly atmospheric, and due to the presence of some matter in unusual quantities. The persistence of the phenomenon, and its great extent, are objections to the view that it is due to aqueous vapor. There would certainly have been, ere this, extensive precipitation, were aqueous vapor the cause; but reports indicate nothing abnormal in the rainfall. Moreover, the glow has been most noticeable when the air has been driest; it has been a characteristic of the cold, dry weather, which attends areas of high barometric pressure. In addition, the spectroscope has confirmed the indications of the psychrometer. The pocket spectroscope shows a very weak rain-band, and a strong development of the bands designated by Piazzi Smyth as α and δ, and ascribed by him to "dry air," the latter known especially as the "low sun-band." The same result has been obtained in England and in America. A careful examination of the spectrum with a powerful grating spectroscope, made at sunset on Dec. 28th, showed that the aqueous lines were feeble; and the spectrum, at its disappearance, was much farther extended towards the green than is usual in a clear sky. From all these considerations, it seems that the hypothesis of an excess of aqueous vapor in the atmosphere is not tenable.

It seems not unreasonable to suppose that the upper regions of the atmosphere have received from some source an accession of light matter which reflects the sunlight. Of the two suggested sources—meteoric dust encountered by the earth in its progress, and volcanic matter projected to an enormous height—either would be a satisfactory explanation. The former would seem in itself the more reasonable, were there not in this instance special considerations which gave additional weight to the latter. Both of these hypotheses have been independently suggested by various writers. Mr. Ranyard advocates the meteoric view in *Knowledge* for Dec. 7th, and Mr. Lockyer the volcanic theory in the London *Mail* of Dec. 10th, and current numbers of *Nature*. English scientific men have shown great interest in this investigation; but few references to it have been made, as yet, in the publications of other countries.

It will be of interest to classify the dates at which the atmospheric phenomenon has been earliest observed in different countries. The following table contains a list of the dates and countries, with the approximate distance and direction of each country from the Straits of Sunda, in which occurred the tremendous volcanic outburst Aug. 26th. It should be noted, that, while the dates given have been collated from the best evidence at hand, there is a possibility that they may be too late in some cases, either from the fact that earlier observations have not been reported, or were not made owing to unfavorable weather; they must therefore be taken as only approximately accurate. A few have been derived from general statements in which the exact dates were not mentioned.

This table has been derived mainly from English periodicals and from the records of the U. S. Signal Service. The important references to New Ireland and the Hawaiian Islands were received by letter from Mr. S. E. Bishop of Honolulu, who has also obtained from shipmasters the information that the phenomenon has been extensively seen on the Pacific Ocean since Sept. 1st. It is also reported from China, but no date is assigned.

An examination of this table shows at once the wide-spread character of the phenomenon, and its progressive motion. It is impossible not to conjecture a connection with the volcanic eruption in the Sunda Straits, by which, on Aug. 26th, the island of Krakatoa disappeared wholly from the face of the earth. The terrible nature of this outburst can hardly be realized; the sky was darkened for several days, the noise was heard two thousand miles, magnetic disturbances were noted, the tidal wave was distinctly felt at San Francisco, and the atmospheric disturbance was sufficient to cause marked barometric fluctuations, which were noted by the barographs on the continent, in England and America, for several succeeding days. Coincidence in dates is not a proof of a connection between the atmospheric and the volcanic phenomena; but it is certain that the former were first observed near the scene of the latter, and that similar atmospheric effects have been heretofore recorded over limited areas in connection with volcanic outbursts. Assuming the origin of the atmospheric effects to be the volcanic eruption, the table shows an extremely rapid progression in both an easterly and a westerly direction—the former over the Pacific Ocean, the latter over the Indian and Atlantic Oceans, to South America and the West Indies. Mr. Lockyer considers that the latter continued westward to

the Hawaiian Islands, and does not regard an eastward progression at all; but the later evidence from the Pacific shows that the phenomenon was seen several thousand miles east of Java on Sept. 1st. This extremely rapid progression has been mentioned as an objection to the volcanic theory, but it is not impossible to believe in its truth; and we

Date.	Country.	Distance and direction from Straits of Sunda.
1883.		*Miles.*
Aug. 28.....	Rodrigues.....	3,000 S.W.
28.....	Mauritius.....	3,500 S.W.
28.....	Seychelles.....	3,500 W.
30.....	Brazil.....	10,500 W.
Sept. 1.....	Gold Coast.....	7,500 W.
1.....	New Ireland.....	3,000 E.
2.....	Venezuela.....	12,000 W.
2.....	West Indies.....	12,000 W.
2.....	Peru.....	13,000 W.
5.....	Hawaiian Islands.....	7,000 N.E.
8.....	Southern India.....	2,000 N.W.
8.....	Ceylon.....	2,000 N.W.
15.....	Southern Australia.....	3,000 S.E.
15.....	Tasmania.....	4,000 S.E.
20.....	Cape of Good Hope.....	6,000 S.W.
Oct. 8.....	Florida.....	13,000 N.W.
19.....	California.....	9,500 N.E.
20.....	Southern United States.....	11,000 N.E.
Nov. 9.....	England.....	7,500 N.W.
20.....	Turkey.....	7,000 N.W.
21.....	United States.....	11,000 N.E.
25.....	Italy.....	7,000 N.W.
26.....	France.....	7,500 N.W.
28.....	Germany.....	7,000 N.W.
30.....	Spain.....	8,000 N.W.
30.....	Sweden.....	7,500 N.W.

know little or nothing of the motions of the higher strata of the atmosphere. Besides, it is not necessary to reckon from Aug. 26th, the date of the volcanic catastrophe; for the volcano had been in eruption since May 20th, and the steamship Siam, on Aug. 1st, in latitude 6° south, longitude 89° east, sailed for more than forty miles over floating pumice. There seems also to be a well-marked southern progression, though the dates for Australia and Tasmania are probably too late.

It is difficult, however, to trace with certainty a progression northward. The October appearances in the United States, and the November appearances in the United States and Europe, if the result of the August eruption, show a rate of progress very much slower than that in an easterly or westerly direction. There seems also to be a gap in the dates; for, with the exception of the three dates in October, there is a September group covering a large territory, and a similar group in November over a different territory. The October records, which are all in the United States, are definite, but few in number. During this month, and up to the 20th of November, there was a well-marked brilliancy in the sunrise and sunset colors over a large portion of the United States, but it did not possess the marked intensity which seemed to suddenly begin after the 20th. It is possible that the sudden in-

crease in the latter part of November, which was noted both in America and in Europe, was due to the arrival over these countries of the volcanic matter which had been moving slowly northwards for ten weeks; and the October appearances may have been either the sequel of the progression towards the West Indies in September, or the forerunner of the later, more marked appearances.

Another explanation, in consonance with the volcanic hypothesis, may be given. The eruption in the Sunda Straits is not the only volcanic outburst of great intensity which has recently occurred, though it has been better known because occurring in an inhabited region. Meagre accounts have been received of a great outburst in Behring Sea, to which brief allusion was made in *Science*, No. 46. The October weather review of the Signal Service contains a letter from Sergeant Applegate, the observer at Unalashka, Alaska, in which he says, referring to some sand which fell in a rain-storm of Oct. 20 :—

"This sand is supposed to have come either from the Mukushin, or the new volcano adjacent to Bogoslov. The former is at a distance of about nineteen miles south-west, but for years has only issued forth smoke or steam. The latter is a new one, which made its appearance this summer, and burst out from the bottom of Behring Sea. It has been exceedingly active, as it has already formed an island from eight hundred to twelve hundred feet high. According to the report of Capt. Anderson, the discoverer, who sails one of the company's vessels, and who went within two thousand yards of it, it presents a most magnificent sight. The fire, smoke, and lava are coming out of many crevices, even under the water-line. Large bowlders are shot high in air, which, striking the water, send forth steam and a hissing sound. Bogoslov is about sixty miles from here, in a westerly direction. The new volcano is about one-eighth of a mile north-west of it."

This makes the position of the volcano, latitude 54° north, longitude 168° west. The San Francisco *Chronicle* of Nov. 23 contains a more detailed report, but adds nothing essential to the above description. As this extensive eruption has been taking place for some months, it is not improbable that the atmosphere has received a large accession of volcanic material from this source also; and possibly to this cause may be due, at least in part, the appearance of the sky in November.

It would seem as if an examination of the dust particles brought to the earth by rain or snow would furnish final proof as to the source of the matter causing the phenomenon, provided that it is not wholly above the influence of the descending precipitation. The force of gravity would certainly eventually bring to the earth portions of the material. It is not uncommon for meteoric matter to be found in the analyses of freshly-fallen snow; and an anonymous writer in the New York *Herald* of December 29th implies that the late snows have given indications of meteoric matter. This, if verified, would tend to confirm the truth of the meteoric theory; but results of quite a different character are announced in *Nature* for December 20th, which has been received since this article was begun. An analysis of fresh snow, made by Mr. McPherson, in Madrid, Spain, revealed the presence of "crystals of hypersthene, pyroxine, magnetic iron, and volcanic glass, all of which have been found in the analysis lately made at Paris of the volcanic ashes from the eruption of Java." Similarly a microscopic examination of a sediment from a violent rain-storm on December 13th, was made at Wageningen, Holland, by Messrs. Beyerinck and Dam, and compared with a sample of ash from Krakatoa. It was found that "both the sediment and the volcanic ash contained (1) small, transparent,

glassy particles; (2) brownish, half-transparent, somewhat filamentous little staves; and (3) jet black, sharp-edged, small grains resembling augite. The average size of the particles observed in the sediment was of course much smaller than that of the constituents of the ash. These observations fortify us in our supposition, expressed above, that the ashes of Krakatoa have come down in Holland."

These analyses certainly tend to confirm the volcanic hypothesis, though it is interesting to note that some of the substances found by Mr. McPherson are also characteristic of meteoric matter. The evidence thus far accumulated seems to point positively to the truth of the volcanic hypothesis. The opponents of this view dwell upon the improbability of so much matter being thrown up to such a great height, and of its remaining so long a time in the atmosphere. But the magnitude of the Java eruption has certainly not been overrated; and the amount of material thrown into the atmosphere from this source alone is probably sufficient to account for the observed effects. If we add the amount from the Alaskan volcano, there is less reason to doubt the ability of the hypothesis to account for the quantity of material required. The objection on the ground of the persistence of the phenomenon has been met by Messrs. Preece and Crookes on electrical grounds. If the matter thrown up is charged with negative electricity, it would be repelled from the earth, and its particles would repel each other, thus causing the rapid dissemination of the material in the atmosphere, and its retention for an indefinite period. The decline of brilliancy has been slow during the time it has been observed in this country. In the Hawaiian Islands it is still a marked phenomenon, after a lapse of several months. We may therefore expect that for some time to come we shall observe it under favorable weather conditions, but that it will gradually become less prominent until it is known only as a fact of past history.—*Science, Jan. 11th*, 1884.

W. UPTON.

SCHOOL OF MINES NOTES.

OBSERVATORY.—The Observatory has been presented by Mr. Lewis M. Rutherfurd with very valuable instruments. These consist of an equatorial telescope of thirteen inches aperture, supplied with a correcting lens for photographic work and the necessary photographic attachments; a very fine micrometer for measuring photographic plates, which is now being used in Washington for measuring the star plates of Dr. B. A. Gould; a fine Dent siderial clock, and a very excellent transit instrument made by Stackpole, of New York City. These instruments are rapidly being put in good order, and it is expected that they will be in place ready for use in a short time.

The college is to be congratulated in having such a friend and supporter as Mr. Rutherfurd, and the hearty thanks of all the alumni and students are due and will be cheerfully given to Mr. Rutherfurd for his timely and generous gift. In a future number we will give a short description of Mr. Rutherfurd's labors, especially in regard to photographic work.

More room will be eventually required by the Observatory, in order that proper instruction may be given to the increasing number of students studying practical astronomy. Now that we have a fine equatorial telescope, with most excellent photographic attachments, it will be possible for the Observatory to do some original work in photographing stars, etc.

It is but just to add in this connection that Mr. Rutherfurd pays all the expenses of moving the instruments to the Observatory and putting them in perfect order. J. K. R.

ASTRONOMY.—The article of Dr. Barnard on the Great Pyramid is calculated to deal a blow against the theory of that class of astronomers and others who, like Piazzi Smyth, the Astronomer Royal of Scotland, believe that the "Sethite Great Pyramid" was built by Divine inspiration, and contains in its elements the value of π, the length of the earth's polar axis, the mean distance of the sun from the earth, etc. The Astronomer Royal of Scotland says, in a recent publication: "But the sun-distances of still earlier ages, and of times still more favored by Divine Inspiration, such as 4,000 and 5,000 years ago, rests on more certain and tangible authority, viz., the Sethite Great Pyramid, already mentioned. And it is something both still, and exactly, measurable; for the grand kosmic meter-yard is found to be symbolized in the chief dimension of that whole building, and practically given as indicating a length equal to 91,840,000 British miles." J. K. R.

GEODESY.—Mr. Jas. T. Gardiner, the Director of the New York State Survey, was shown the other day the angle note-books of the Summer Class in Geodesy, and remarked that the work done was very satisfactory. A detailed report of the work of the last two classes will shortly be made to the State Survey Office. J. K. R.

THE NEW COURSE IN ASSAYING.—The enlargement of the Assay Department of the School was first proposed in the fall of 1882, and a plan or course of instruction submitted to the Trustees. The object in view is to render the course more practical and to give the student greater familiarity with the working details of the treatment and assay of the ores of the precious metals, as followed at the mines and in the mills and metallurgical works of the West. The importance and necessity of such an addition to the assay laboratory of the School is obvious, if we take into consideration the fact that fully 40 per cent. of our graduates commence their professional work as assayers in the West and elsewhere. The positions they are called upon to fill demand not only a knowledge of how to assay, but also how to sample ores, furnace products, bullion, etc. In the past, to instruct the student other than by lecture, in the details of such work, has been impossible; but by following out the plans submitted to and approved by the Trustees, it is believed that a step forward in the training of the student will be taken, which cannot fail to prove of immense practical advantage to the graduate. The course proposed includes laboratory practice in the assay of ores and alloys as heretofore taught, but instead of the student receiving a small hand-sample of the material to be tested, he will be required to draw the sample from, and average it upon, large lots of ore, etc., and by his assays direct some method of treatment, such as amalgamation on plates or in pans, concentration by jigging, or on tables, etc. To do this the machinery and appliances must be at hand, and the Trustees have authorized the erection, in the room in the Fourth Avenue building, of the necessary plant. This will, as far as has been determined, include—

1st—Arrangements for sampling large and small lots of ore. These will consist of crushers, rolls, sizing sieves, Hendrie and Bolthoff pulverizer, sampling and grinding plates.

2d—Appliances for milling and amalgamation, such as small stamp mill, plates, steam-jacketed pan, settler, retorting apparatus for amalgam, etc.

3d—Concentration appliances, both by hand and machine work, such as pans, jigs, Frue vanner, Imlay table, etc.

4th—Furnaces for roasting and smelting, with small plant for making leaching tests of chloridized ore.

The machinery will be run by two engines, one 15 horse power for crushers, stamps, etc., and one small engine for light work. Much of the machinery has been donated by friends of the School interested in anything which looks to practical instruction, and the Trustees have granted an appropriation for placing the same in position. A list of the donators will be given as soon as the laboratory is complete. This it is expected will be in the near future, as the engines and some of the other machinery have already been delivered. In order to make the plant as practical as possible, it is designed to have the arrangement of the machinery, as far as the space assigned will permit, the same as is usual in milling and concentrating ores on a large scale. In following out the course of instruction proposed, lots of say 1,000 lbs. of ore in lump will be given out to the student, who will be required to

sample and assay the same, and then, from the assay and mineral characteristics of the ore, determine upon a method of treatment. Say the ore is one which should be concentrated—he will size it, concentrate by different methods, assay the concentrates, middlings, tailings, etc., and make up a clear statement as to the method and the results, giving his opinion founded upon the facts observed, as to how the ore should be treated. Thus the student will learn how to sample and how to assay, and will also obtain some knowledge of mill concentration and furnace work. It is of course evident that in a small laboratory there is much, such as practical furnace work, etc., which cannot be taught in detail, but an outline can be given which will be of immense advantage to the student, and principles can be illustrated better than by models and blackboard exercises. He will also have the advantage of handling and working upon the various products resulting from the treatment of the ores of the precious metals, and familiarizing himself with them. While such a course will not give the student that full experience which only comes by extended practice, it is hoped that in connection with the opportunities afforded him during vacation to visit and inspect similar work done on a large scale, it will prove advantageous to the student, and increase the efficiency of the School.

P. DE P. R.

ENGINEERING SOCIETY OF SCHOOL OF MINES.—The papers read and subjects discussed at the several meetings of the Engineering Society held in Oct., Nov. and Dec. were as follows :

Oct. 26, 1883.—Paper : "The School of Mines in Europe."—B. Ripinsky.

Discussion : "The influence of a current on boats."

Nov. 9, 1883.—Paper : "The system of elevating street cars in use at Hoboken, N. J."—A. J. Lamb.

Nov. 23, 1883.—Paper : "The new cantilever bridge over the Niagara River."—E. G. Barratt.

Debate.—Resolved: That it is advisable to add a fifth year to the course of Engineering in the S. of M., to be devoted to projects and special work now required in the four-years course.

Dec. 8, 1883.—Paper : "Processes of Milling and Mining Talc." —W. Newbrough.

Discussion : The proposed change of name of the School of Mines.

Up to date two lectures have been delivered before the Society: the first by Prof. J. K. Rees, and the other by Prof. W. R. Ware.

The former was given on Nov. 15, 1883, and entitled "The Proposed New Time Standards of the United States," the subject being peculiarly appropriate as the new system was to go into effect on November 18.

The speaker called attention to the history of time-keeping in different parts of the world, and traced the development of the new system

from its earliest conception to its complete adoption throughout the United States.

Prof. Rees also spoke of the proposal to number the hours from one to twenty-four consecutively so as to obviate the necessity of using A.M. or P.M. to indicate whether morning or afternoon is meant. Mention was also made of "Cosmic time" by which any one can tell at what hour of Greenwich time any event occurs. The latter is intended particularly for the use of scientific men to facilitate the reduction of observations to Greenwich time. In this system, New York would have R time and San Francisco U time, other meridians using other letters beginning with M at Greenwich, Eng.

The lecture by Prof. Ware, on Dec. 14, 1883, was entitled "Mediæval Vaultings," and was illustrated by a large number of magnificent lantern views. The lecture began with references to the Roman vaultings, characteristic points being dwelt upon so that comparisons could be made with the later methods and styles. The development of the Gothic vaultings was traced from the plain cylindrical vaultings of the Romans through all the processes of adornment to which they were subjected, finally ending in the vaulting and arching of which the English cathedrals are the richest examples.

The lecturer gave accurate descriptions illustrated with views of the manner of cutting and laying the stones of the different parts of the arches, pillars, etc. E. G. B.

SCHOOL OF MINES CHEMICAL SOCIETY.—Officers for the first term. W. W. Burritt, *President;* W. M. Baldwin, *First Vice-President;* J. F. Carter, *Second Vice-President;* W. Moeller, *Secretary;* W. Bryce, Jr., *Treasurer.*

Oct. 16, '83.—A special meeting was held for the purpose of electing a member of the Quarterly Board of Editors in the place of Mr. Burritt, resigned. Mr. McLaughlin was unanimously elected. A committee on public lectures was appointed, consisting of Messrs. Rood, Bryce, Baldwin and Burritt (ex officio.)

Nov. 14, '83.—*Paper:* "Varnishes." C. S. McLaughlin. The Society casts its vote in favor of granting the Editors of the QUARTERLY the power of accepting or rejecting papers offered them for publication in the QUARTERLY by persons who are not, or who never have been connected with the School of Mines.

Dec. 6, '83.—*Paper;* "Logwood and its extracts."—W. M. Baldwin.

Messrs. Hollis, Dwight, Huntting, Cox and H. C. Carter were elected to active membership.

Messrs. McKenna, Weed and Bullman were elected honorary members of the Society.

Dec. 19, '83.—*Lecture:* "The Geysers of the Yellowstone—their Chemistry and Geology" (lantern illustrations).—Prof. J. S. Newberry.

GRADUATE DEPARTMENT.

OFFICERS AND MANAGERS FOR 1884.—In response to the circulars and ballots sent out by the Secretary on November 24, 1883, two hundred and three votes were received, the total membership of the Alumni Association being three hundred and sixty-seven. The managers elected for the year 1884 are as follows: Class of '67, A. W. Hale (re-elected); Class of '68, F. Augustus Schermerhorn (re-elected); Class of '69, W. A. Hooker (succeeds H. S. Munroe); Class of '70, Elwyn Waller (re-elected); Class of '71, P. de P. Ricketts (re-elected); Class of '72, F. H. McDowell (succeeds P. T. Austen); Class of '73, F. A. Canfield (succeeds H. W. Webb); Class of '74, B. F. Rees (succeeds W. de L. Benedict); Class of '75, J. K. Rees (re-elected); Class of '76, F. R. Hutton (re-elected); Class of '77, A. C. Canfield (succeeds D. H. Norris); Class of '78, W. P. Butler (succeeds W. G. Elliott); Class of '79, N. L. Britton (succeeds Knight Neftel); Class of '80, A. L. Beebe (re-elected); Class of '81, A. H. Van Sinderen (succeeds A. L. Colby); Class of '82, A. J. Moses (re-elected); Class of '83, J. H. Banks. The new Board met at the Buckingham Hotel at 6.30 P.M., December 27, 1883, for organization and election of officers. The following were elected as officers of the Association for the year 1884:

President—F. Augustus Schermerhorn.
First Vice-President—W. A. Hooker.
Second Vice-President—A. J. Moses.
Third Vice-President—A. L. Beebe.
Treasurer—J. K. Rees.
Secretary—P. de P. Ricketts.

The following report was received from the Treasurer, which is printed in full, as being of interest to the members of the Association:

NEW YORK, Dec. 27, 1883.

Balance received from last Treasurer	$27 36
Total receipts for 1883 to date	948 40
Making grand total	$975 76
Total expenditures for 1883	501 70
Leaving balance in Treasurer's hands	$474 06
Due SCHOOL OF MINES QUARTERLY, for subscriptions	120 00
Leaving net balance of	$354 06

The President appointed Messrs. J. H. Banks and W. P. Butler to audit the Treasurer's accounts.

THE ALUMNI DINNER.—The Fourteenth Annual Reunion and dinner of the Association was held at the Buckingham Hotel, Fiftieth Street and Fifth Avenue, on December 27, 1883, at 8 P.M. The *menu*, was discussed by some twenty-seven members of the Association at the festive board, over which the President of the association, F. Augustus Schermerhorn, presided.

The toasts were arranged by Dr. F. R. Hutton, one of the Dinner Committee, and Toast Master for the occasion. Those who remember the success attending Dr. Hutton's efforts last year, when filling the same responsible position, need not be told that the enjoyment of those present was much enhanced by his happy and humorous manner of performing a truly thankless task. Who has ever heard of a Toast Master that did not receive a "blessing" from every speaker called upon?

Below will be found a list of the toasts, and the names of those responding thereto. The happy efforts of Messrs. Lawrence and Butler in solo and as chorus leaders added greatly to the general felicity.

The attendance, though smaller than usual, was sufficient to make the dinner a successful and very jolly affair.

TOASTS

1. OUR ALMA MATER.
   F. Augustus Schermerhorn.
2. OUR ALLIED PROFESSIONS.
   "With us these are but matters of course." *F. R. Hutton.*
3. THE INTELLIGENT OFFICER OF OUR ASSOCIATION.
   "He runs our Intelligence Office." *P. de P. Ricketts.*
4. OUR EARLY GRADUATES.
   "The early bird catches the worm." *A. W. Hale.*
5. THE SUMMER BUMMER.
   "How doth the little busy B——
   Delight to bark and bite." *J. K. Rees.*
6. THE SCIENTIFIC PRESS.
   "You shall be hung, drawn and Quarterly-ed." *J. B. Mackintosh.*
7. THE DEVOTEES OF SCIENCE. Believe in Ore-icular confession—
   "Peck 'av I." *B. B. Lawrence.*
8. THE REIGN OF LAW.
   "It never rains but it pours." *W. P. Butler.*
9. IMPROMPTU TOASTS.
   "After us—the Deluge." *Messrs. Waller, Colby and others.*

GRADUATE ADDRESSES.—The attention of members of the Association is called to the fact that hereafter the address list of graduates will appear in the *January* number of the QUARTERLY only. This will insure the publication of a full and correct list, as this number appears immediately after the Annual Reunion. A list will be kept by the Secretary, and graduates are requested to notify that officer of any change of address, without waiting for the annual notices.

PROPOSED CHANGES IN THE ALUMNI MEETINGS.—It has been proposed by some of the members of the Alumni Association to so amend the Constitution as to change the system of holding the meetings of the society. At present we have four meetings called "Quarterly Meetings," on the first Wednesdays of October, December, February and April, and one annual reunion and dinner on the last Thursday in December. The plan proposed will do away with the annual reunion, and change the date for holding the "Quarterly Meetings." Under the new system there will be four meetings a year of the Association, viz., on the last Wednesdays of October, December, February and April, unless otherwise ordered by the Board of Managers. These meetings are to be of a literary and social nature. Papers may be read, if previously presented to the Board of Managers and approved of by them, to be after-

wards published in the SCHOOL OF MINES QUARTERLY in connection with an account of the meeting at which the papers were read. Communications from persons interested in science may also be read and published, although such persons may not have any connection with the school or the association. The annual election of managers and officers to be held as at present. The votes to be counted five days before the December meeting and the officers elected at said meeting. It is thought that the foregoing plan will not only carry out the idea of social intercourse as well as the dinner system, but also do more to promote the objects and usefulness of the association. No action has as yet been taken on the matter, but, as it is of such general interest to graduates, it is thought best to present it for criticism.

TREASURER'S NOTICE.

The attention of every member of the Alumni Association who has not paid his dues for the school year 1883–84 is called to the following Article from the new Constitution :

ARTICLE XI.—DUES.

Section 1.—The annual dues of this Association shall be two dollars, payable on or before the first day of October in each year. Any member, by the payment of one dollar additional, shall be entitled to receive one copy of the SCHOOL OF MINES QUARTERLY for the year for which his dues are paid.

Section 2.—Any member not in arrears may become a Life Member, and be relieved from further payment of annual dues by the payment at any one time of thirty dollars.

Section 3.—Members three years in arrears in payment of annual dues may, after due notification, be dropped from the rolls, and shall then forfeit their rights and privileges in the Association until all arrears be paid.

Section 4.—Only those members not in arrears shall be entitled to vote or hold office.

All understand that in order to place the Alumni Association on a firm basis we must be able to collect the dues promptly. Previous to this year the dues were a voluntary contribution, now they are required, as is the case in all alumni associations.

The Treasurer has received some one hundred and fifty payments of dues for this year, all (with two exceptions) of $3.00, which includes the SCHOOL OF MINES QUARTERLY. All Alumni are urged strongly to support the only scientific publication of the SCHOOL OF MINES and the official organ of the Alumni Association.

J. K. REES,
Treasurer Al. Assoc. S. of M.

LIST OF GRADUATES.

First graduate of the School of Mines: John Magnus Adams, A.B., A.M., E.M., Mining and Mechanical Engineer, Agent for Frue Vanner, etc., 109 California Street, Room 7, San Francisco, Cal.

1867.

Samuel Willard Bridgham, E.M., 49 West Twenty-third Street, New York City.
Francis Gordon Brown, E.M., Merchant, 116 East Twenty-seventh Street, New York City.

Edward Steele Bronson, A.B., A.M., E.M., Prospect Park, Brooklyn. Residence, 144 Hicks Street, Brooklyn, N. Y.
John Adams Church, E.M., Ph.D., Superintendent Tombstone Mill and Mining Co., Tombstone, Arizona.
Henry Bedinger Cornwall, A.B., A.M., E.M., Professor of Analytical Chemistry and Mineralogy, College of New Jersey, Princeton, N. J.
Edward Everett Giddings, E.M., Merchant, 21 Metropolitan Block, Chicago, Ill.
Charles King Gracie, A.M., E.M., 71 Broadway, New York City.
Albert Ward Hale, A.B., A.M., E.M., Civil and Mining Engineer, 71 Broadway; Residence 47 W. 35th Street, New York City.
Thomas Hayes Harmer, A.B., A.M., E.M., 113 East Thirty-seventh Street, New York City.
Frederic Milton Heath (formerly Petit), E.M., Potsdam, Saint Lawrence County, N. Y.
William Wey Tuttle, E.M., Lexington, Mo.
David Van Lennep, E.M., Auburn, Placer Co., Cal.

1868.

Augustus Porter Barnard, E.M. Address care of D. Van Nostrand, 23 Murray Street, New York City.
George Strong Baxter, A.B., E.M., Mining and Civil Engineer, Cashier North Pacific Railroad, 23 Fifth Avenue, New York City.
James Pettigrew Carson, E.M., Mining Engineer. Address, 71 Broadway, New York City.
Albert Huntington Chester, A.M., E.M., Ph.D., Childs Professor of Agricultural Chemistry, Hamilton College, Clinton, Oneida County, N. Y.
George Hampton Coursen, E.M.,C.E., 307 Greenwich Street, New York City.
George Jarvis Geer, Jr., E.M., Merchant, 453 Broome Street, New York City.
George Byron Hanna, A.B., E. M., Melter, U. S. Assay Office, Charlotte, N. C.
* Archibald MacMartin, A.B., A.M., E.M., Editor and Metallurgist, 168 Fifth Avenue, New York City. Died in New York City, May 7, 1881.
Edward Stuart Moffatt, A.B., A.M., E.M., Assistant General Manager, Lackawanna Iron and Coal Company, Scranton, Pa.
George Howland Parsons, E.M., Superintendent of Land Improvement Company, Colorado Springs, Col.
William Pistor, E.M., Hamilton & Pistor, Architects, 35 Broad Street, New York. Residence, 136 East Thirty-seventh Street, New York City.
Charles Slason Platt, E.M., Assayer, 4 Liberty Place, New York City.
Kenneth Robertson, E.M., care of Passaic Zinc Works, Jersey City.
Albert P. Schack, E.M., Ministry. 63 Auburn St., Paterson, N. J.
Frederick Augustus Shermerhorn, E.M., Trnstee of Columbia College. Address, 61 University Place, New York City.
Lenox Smith, A.B., E.M., Steel Rails, 46 Pine Street, New York City. Trustee of Columbia College.
William Allen Smith, E.M., Secretary Iron and Metal Exchange Company (Limited). Address, 16 Exchange Place, New York City.
Frederick Stallknecht, E.M., Editor, 133 West Thirteenth Street, New York City.
William Henry Van Arsdale, A.B., A.M., E.M., Vice-President Aurora Smelting and Refining Company, Aurora, Ill.
Moses Dillon Wheeler, A.B., E.M., P. O. Box 231, Stapleton, Richmond County, Staten Island, N. Y.

1869.

* Thomas Monahan Blossom, A.B., A.M., E.M. Died, October, 1876, in California.
Frederick Bruckman, E.M., 125 East Eighth Street, Leadville, Col.
Alonzo Clarence Campbell, E.M., Chemist and Mining Engineer, 227 Shelby Avenue, Nashville, Tenn.
William Augustus Hooker, A.B., A.M., E.M., Consulting Geologist and Mining Engineer; office, 2 Wall Street, New York City.
Roland Duer Irving, A.M., E.M., Ph.D., Professor of Geology and Mineralogy in the University of Wisconsin, Madison, Wisconsin, and United States Geologist in charge of survey of crystalline rocks of the Northwestern States.
Walter Proctor Jenny, E.M., Ph.D., Consulting Engineer and Geologist. Address, care of S. Jenny & Son, 128 Pearl Street, New York City.

Henry Smith Munroe, E M., Ph.D., Adjunct Professor in Surveying and Practica Mining, School of Mines, Columbia College, New York City.
Lionel Robert Nettre, E.M., Superintendent of the Gregory Consolidated Mining Company, Helena, Lewis and Clarke County, Mont.
* Henry Newton, A.B., E.M., Ph.D. Died, August 5, 1877, at Deadwood City, Dak. Ter., while occupied as Assistant Geologist of Black Hills Expedition.
William Bleecker Potter, A.B., A.M., E.M., Professor of Mining and Metallurgy, Washington University, St. Louis, Mo.
John Cooper F. Randolph, A.B., A.M., E.M., Consulting Engineer, 35 Broadway, New York City.

1870.

Ogden Haight, E.M., Stock Broker, 38 Broadway, New York City.
William Halsey Ingersoll, A.B., A.M., LL.D., E.M., United States Stamping Company, Portland, Conn.
John Augustus Knapp, A.B., A.M., E.M., General Manager Mingo Furnace, P. O. Box 515, Salt Lake City, Utah.
John Leo Lilienthal, E.M., P. O. Box 2258, San Francisco, Cal.
Stuart Lindsley, E.M., Orange, N. J.
Edward Moore Parrot, E.M., Parrot Iron Company. P. O. Address, Greenwood Iron Works, Orange Co., N. Y.
Richard Henry Terhune, E.M., Superintendent of the Morgan Silver Smelting Company, Salt Lake, Utah.
Theodore Francis Van Wagenen, E.M., General Manager Twin Lakes Hydraulic Gold Mining Syndicate, Leadville, Col.
Elwyn Waller, A.B., A.M., E.M., Ph.D., Instructor in Analytical Chemistry, School of Mines, Columbia College, and Chemist to the New York Board of Health, New York City.

1871.

William E. S. Fales, A.B., E.M., LL.B., Counsellor-at-Law, 189 Montague Street, Brooklyn, N. Y.
Samuel Anthony Goldschmidt, A.B., E.M., Ph.D., Manufacturing Chemist, Columbia Chemical Works, 66 Water Street, Brooklyn, N. Y.
John Gordon, Jr., E.M. Address, care E. Johnson & Co., Rio Janeiro, Brazil.
Pierre de Peyster Ricketts, E.M , Ph.D., Instructor in Assaying, School of Mines, Columbia College, New York City.
George Washington Riggs, Ph.B., 12 West Twenty-second Street, New York City.
Gracie Sayre Roberts, E.M., C.E., Topographical Engineer, Department of Public Works, Sixty-fourth Street and Fifth Avenue, Central Park, New York City. Residence, 88 Union Avenue, Brooklyn, E. D., N. Y.
Richard Spotswood Robertson, Jr., E.M., with Carnegie Bros. & Co., Pittsburgh, Pa.

1872.

Peter Townrend Austen, Ph. D., F.C.S., Professor of General and Applied Chemistry, Rutgers College, New Brunswick, N. J.
* Frank B. Jenny, E.M. Died in Trinidad, 1876, while engaged as Superintendent of the Orinoco Exploring Company.
Frederick H. McDowell, E.M., Beckett & McDowell, 120 Liberty Street, New York City.
Thomas O'Connor Sloane, A.B., A.M., E.M., Ph.D., Chemist, 119 Pearl Street, New York City.
Authur F. Wendt, E.M., C.E., Consulting Engineer, 10 Cedar Street; residence, 414 East Fifty-first Street, New York City.

1873.

Frederick A. Canfield, A.B., A.M., E.M., Consulting Engineer, Dover, N. J.
Charles Adams Colton, E.M., Professor, Rose Polytechnic Institute, Terre Haute, Indiana.
Henry Augustus Mott, Jr., E.M., Ph.D., Mining Engineer and Analytical Chemist, 61 Broadway, Room 56, New York City.
Henry Walter Webb, E.M., Broker; residence, 14 West Thirty-eighth Street New York City.

John Townsend Williams, E.M., Ph.B., East River Chemical Works, Forty-fourth Street and East River, New York City.

1874.

Charles Sumner Allen, Ph.B., M.D., Practising Physician, 109 East Eighty-sixth Street, New York City.
William de Liesseline Benedict, E.M., Benedict & Cole, 61 Liberty Street, New York City.
John Gedney Mott Cameron, E.M., C.E., Assayer, Spears & Howard. Address, Fifty-fifth Street and Madison Avenue, New York City.
Samuel Morris Lillie, E.M., Chemist, Harrison, Havemeyer & Co., 101 South Front Street, Philadelphia; residence, 307 Pine Street, Philadelphia, Pa.
George Murray, E.M. City address, 235 West Twenty-third Street, New York City.
Eben Erskine Olcott, E.M., Superintendent St. Helena Gold Mine, Delicias, Sonora, Mex. Address, 111 West Thirteenth Street, New York City.
Benjamin Franklin Rees, E.M., Merchant, 37 Ferry Street, New York City.
Francis Bell Forsyth Rhodes, E.M., Superintendent Mingo Works, near Salt Lake, Utah.
Frederick Harrison Williams, E.M. Care of W. Williams, Orange, N. J.

1875.

Magnus C. Ihlseng, E.M., C.E., Ph.D., Prof. of Engineering, State School of Mines, Golden, Col.
Malvern Wells Iles, Ph.D., Metallurgist, Omaha and Grant Smelting and Refining Company, Denver, Col.
Charles Edward Jackson, C.E., Assistant Engineer, Brooklyn Elevated Railroad Company. Address, 122 East Nineteenth Street, New York City.
Douglas Arad Joy, E.M., Assistant in Chemistry, University of Michigan, Ann Arbor, Mich.
* Robert Schuyler Lamson, C.E., Major in the Egyptian Army. Died at Darbour, Upper Egypt, 1876.
Harry Wenman Leavens, E.M., Denver Ore Sampling Co., Denver, Colorado.
Arthur Macy, Ph.B., C.E., Silver King Mining Co., Silver King, Pinal, Arizona. Address, 609 Lexington Avenue, New York City.
William Skaats Noyes, E.M., Oakland, Cal.
Philip Charles Pfister, E.M., Black & Pfister, 142 Maiden Lane, New York City.
Franklin Pool, E.M., Chemist, Celluloid Manufacturing Company, Newark, N. J.
Bayard Taylor Putnam, E.M., Northern Trans-continental Survey, Newport, R. I.
John Krom Rees, A.B., A.M., E.M., Adjunct Professor in Geodesy and Practica Astronomy and Director of the Observatory, Columbia College, New York City.
Charles M. Rolker, E.M., Mining Engineer, 63 Broadway, New York City.
Samuel Howland Russell, E.M., 417 Fifth Avenue, New York City.
Hunter Stewart, E.M., Civil Engineer. Address unknown.
Milton Strong Thompson, Ph.B., Chemist, Chrolithion Manufacturing Co., Newburyport, Mass.
John Henry Tucker, Ph.D., Superintending Chemist, Philadelphia Sugar Refinery, 225 Church Street, Phila., Pa.
James Simpson Chester Wells, Ph.D., Instructor in Analytical Chemistry, School of Mines, Columbia College, New York City.
Edwin Atwater Wetmore, E.M. Care of E. A. Wetmore & Co., Iron Merchants, Marquette, Mich.
Albert Allen Wright, A.B., A.M., Ph.B., Prof. Geology and Natural History, Oberlin College, Oberlin, O.

1876.

Thomas Septimus Austin, E.M., Supt. Germania Smelting Works, Salt Lake, Utah.
Frederick Everett Bruen, E.M., C.E., P. O. Box 16, Leadville, Col.
Francis Sanderson Craven, E.M., C.E., Supt. Denver Gold Co. (Limited), of London, England, Bald Mountain, Gilpin Co., Col.

George Rockwell Cornwall, E.M., C.E., Mining Engineer, Gunnison City, Col.
Herbert Carrington Foote, C.E., Professor of Chemistry, Central High School and Homeopathic Hospital College. Address, 37 Arlington Court, Cleveland, O.
Edmund Hyatt Garrison, E.M., C.E., Asst. Treas. Central Park, N. and E.R.R.R. Co., Tenth Avenue and Fifty-third Street, New York City.
Louis Pope Gratacap, Ph.B., M.A., Curator Am. Museum of Natural History, Central Park, New York City.
Robert William Hall, E.M., American Gas, Fuel and Light Co., 139 Broadway, New York City.
Schuyler Hamilton, Jr., A.B., A.M., E.M., Hamilton & Pistor, Architects, 35 Broad Street, New York City.
Francis Newberry Holbrook, C.E., El Paso, Texas. Address, care J. P. Holbrook, 254 Broadway, New York City.
Walter Lowrie Hoyt, E.M., C.E., Chemist and Assayer, Omaha and Grant Smelting and Refining Company, Omaha, Neb.
Frederick Furneaux Hunt, E.M., C.E., 4 Pemberton Square, Boston, Mass.
Frederic Remsen Hutton, A.B., A.M., E.M., C.E., Ph.D., Adjunct Professor in Mechanical Engineering, School of Mines, Columbia College. Address, 6 W. Thirty-third Street, New York City.
Charles King, Ph.B., Railway Contractor, 68 Wall Street, New York City.
Nathaniel Wright Lord, E.M., Professor of Mining and Metallurgy, Ohio State University, Columbus, Ohio.
Edward Gurley Love, A.B., A.M., Ph.D., Tester of ill. gas, Dept. of Public Works, New York; Examiner in Chem., College of Physicians and Surgeons. Address, School of Mines, Columbia College, New York City.
John Holme Maghee, A.B., A.M., C.E., 16 East Fifty-fourth Street, New York City.
Henry Francis Morewood, E.M., Importer, 34 South Street, New York City.
James William O'Grady, E.M., C.E., Horne Street, opposite Villa Place, Morrisania, New York.
James Fitz Randolph, E.M., C.E. 111 Broadway, (Room 40), New York City.
William Coleman Ross, E.M., C.E., Silver City, Grant Co., New Mex.
Albert Francis Schneider, E.M., C.E., Supt. G. Billings Smelting Works, Box 211, Socorro, Mexico.
George Cyrus Tilden, C.E., Mining Engineer, Golden, Col.
Elbert Champlin Van Blarcom, C.E., Tombstone, Ariz. Address, P. O. Box 2085, San Francisco, Cal.
Augustus Clark Walbridge, E.M., C.E., Builder, 120 Broadway, New York City.
James Robert Wardlaw, C.E., 39 Nassau Street, Room 31, New York City.

1877.

Louis de Souza Barros, C.E., E.M., San Paulo, Brazil.
James Thom Beard, E.M., C.E., 103 St. James' Place, Brooklyn, N. Y.
Edward Behr, C.E, Piano Manufacturer, 42 Union Square, New York City.
Charles Ramsay Buckley, A.B., A.M., E.M. Address, 35 Broadway, Room 69, New York City.
Linus Bertram Cady, E.M., C.E., in Michigan. Address, 234 West Thirty-eighth Street, New York City.
Augustus Cass Canfield, E.M., 60 West Fifty-fourth Street, New York City.
John Britton Cauldwell, C.E., 6 East Forty-ninth Street, New York City.
* Henry Gilbert Clark, E.M., C.E., late Supt. Cortez Mining and Milling Co., Aurora, Nev. Died of Typhoid fever, August 2, 1881.
Charles Edward Colby, E.M., C.E., Private Assistant to Professor C. F. Chandler. Schools of Mines, Columbia College, New York City.
Charles Louis Constant, E.M., C.E., T. J. Hojer & Co., Paints, 936 Third Avenue, New York City.
George Birdsall Cornell, E.M., C.E., Civil Engineer, Asst. Eng. Bridge Dept., N. Y., W. S. & B. R. R., Mills Bldg. Residence, 46 West Forty-eighth Street, New York City.
Frederick William Floyd, E.M., C.E., Oregon Iron Works, 539 West Twentieth Street, New York City.
* Frank Stuart Helleberg, C. E., late Assayer and Chemist, Cummings & Finn Smelting Works, Leadville, Col. Died, October 4, 1883.

Walter Edwards Hildreth, E.M., C.E., Consulting Engineer, 52 Broadway, Room 48, New York City.
Axel Olaf Ihlseng, B.S. E.M., C.E., 151 East Thirty-third Street, New York City
Jose Nabor Pacheco Jordao, C.E., E.M., Ph.D., Paulista Railroad, San Paulo, Brazil.
William Kelly, A.B,, E.M., Superintendent Kemble Coal and Iron Co., Riddlesburg, Bedford County, Penn.
James Buckton Mackintosh, E.M., C.E., Private Assistant to Dr. Egleston, School of Mines, Columbia College. New York City.
John Glenville Murphy, E.M., C.E., 409 Lexington Avenue, New York City.
Ralph Nichols, E.M., C.E., Viola Mining and Smelting Co., Camas, Lava P. O., Idaho.
Dudley Hiram Norris, E.M., Lawyer, 35 Wall Street, New York City. Residence, 112 Lafayette Avenue, Brooklyn, N. Y.
* James Robert Priest, E.M., C.E., late School Teacher and Surveyor, Greenville, Sinon County, Liberia, Africa. Died, 1880.
William Helsham Radford, E.M., North Bloomfield, Nevada Co., Cal.
Sylvanus Albert Reed, A.B., E.M., Rose and Reed Milling Co., Irwin, Gunnison County, Col.
Charles Lewis Rogers, E.M., C.E. Address unknown.
Edward Eugene Sage, C.E., Assistant Assayer, United States Assay Office, New York City.
William Henry Smeaton, C.E., E.M., Mt. Vernon, Westchester Co., N.Y.
Roland Mulville Smythe, E.M., C.E., 539 Henry Street, Brooklyn, N. Y.
Arthur Thacher, E.M., C.E., 61 Broadway, Room 25, New York City.
Robert Ward Van Boskerck, C.E., Artist, studio, Sherwood Building, 58 West Fifty-seventh Street, New York City.
Cornelius Reed Waterbury, C.E., Engineer and Surveyor. Care of Leonard & Company, 150 Broadway, New York City.

1878.

William James Adams, A.B., A.M., E.M. Address, 109 California Street (Room 7), San Francisco, Cal.
Marcus Benjamin, Ph.B., 132 Nassau Street, Room 20; residence, 43 East Sixty-seventh Street, New York City.
Charles Edward Blydenburgh, A.B., A.M., E.M., Mining Expert and Prospector, Rawlins, Wyo. Ter.
Robert Elmer Booraem, E.M., Asst. Supt. Evening Star Mining Co., Leadville, Colorado.
George Charles Brinckerhoff, E.M. Address, Apartado 183, Matanzas, Cuba.
Willard Parker Butler, E.M., LL.B., Counsellor-at-Law, and Solicitor of Patents, 59 Wall Street, New York City.
Alexander Ramsy Cushman, Ph.D., 128 East Sixteenth Street, New York City.
John Woodbridge Davis, C.E., Ph.D., Principal, School of Mines Preparatory School, 32 West Forty-fifth Street, New York City.
Walter B. Devereux, A.B., A.M., E.M., Supt. Aspen Smelting Co., Aspen, Colorado. Address, 219 West Eleventh Street, New York City.
Isaac Wyman Drummond, E.M., Ph.D., Chemist, F. W. Devoe & Co., corner Fulton and William Streets, New York City.
Orrien Pinkerton Downing, Ph.B., San Leandro, Cal.
Walter Graeme Elliot, E.M., C.E., Ph.D., Elliot & Hooper, Consulting Sanitary Engineers, 252 Broadway. Residence, 250 West Forty-second Street, New York City.
Anton Fernekes, E.M. Care Colorado Boot and Shoe Mfg. Co., Box 1884, Denver, Colorado.
Harry Leopold Haas, Ph.B., Zucker & Levett Chemical Co., 540 West Sixteenth Street, New York City.
Yothinosuke Hasegawa, E.M., Ph.D., Engineer, Yashioka Copper Mine, Bitchu, Japan. Address, University of Tokio, Tokio, Japan.
* Henry Albert Hodges, E.M., late Chief Clerk, Wm. D. Andrews & Bros., Drive Wells, 23 Broadway, New York City. Died July, 4th, 1883.
Edward Henry Holden, C.E., Surveyor and Civil Engineer, One Hundred and Sixty-ninth Street and Boston Avenue, Morrisania, N. Y.

William Hollis, C.E., Mining Expert, Galveston, Harrisburg and San Antonio Railroad, San Antonio, Texas.
Elias Mattison Johnson, Ph.D., I. G. Johnson & Co., Malleable Iron, Spuyten Duyvil, N. Y.
Gilbert Henry Johnson, Ph.B., Chemist, I. G. Johnson & Co., Spuyten Duyvil, N. Y.
Corydon Powell Karr, Ph.B., 30 Wardsworth Park, Buffalo, N. Y.
Benjamin Bowden Lawrence, E.M., Superintendent and Mining Engineer, Montezuma Silver Mining Co., Montezuma, Col. Address, 238 East Thirteenth Street, New York City.
Frank Lyman, A.M., E.M., Manager Stack Mine, Backbone, Alleghany Co., Va.
Edward Austin McCulloh, Ph.B. Address, P. O. Box 2346, New York City.
Nawokichi Matsui, Ph.D., Instructor in Qualitative Analysis, University of Tokio, Tokio, Japan.
George Barrow Morewood, E.M., Ph.B., Tea Importer, 121 Front Street, New York City.
Gouverneur William Morris, E.M., Meyers, Rutherford & Co., 58 Wall Street, New York City.
Charles Edward Munsell, Ph.B., Milk Inspector, New York Health Department, 128 Worth Street, New York City. Address, Glen Cove, L. I.
Henry Morgan Murphy, E.M., Murphy & Co., 231 Broadway, New York City.
Kingo Nambu, E.M., Engineer, Takashima, Coal Mine, Hizen, Japan. Address, University of Tokio, Tokio, Japan.
Spencer Baird Newberry, E.M., Ph.D., Professor of Chemistry, Agricultural Department, Cornell University, Ithaca, N. Y.
James Atkins Noyes, Ph.B., A.B. Address, 155 Remsen Street, Brooklyn, N. Y.
*Owen Frederick Olmsted, C.E. Died at Albany, N. Y., November 21, 1881.
Frederick Nash Owen, E.M., Civil and Sanitary Engineer, 96 Fulton Street, New York. Residence, 19 West Fifty-sixth Street, New York City.
Cortlandt Edward Palmer, E.M., Engineer, North Brother Island Hospital. Address, 25 Madison Avenue, New York City.
Richard Alexander Parker, C.E., care of Brown Bros. & Co., 59 Wall Street, New York City.
Vicente Felix Pazos, E.M., 122 Calle Zavala, Lima, Peru.
Nelson Williams Perry, E.M., Pinos, State of Zacatecas, Mexico.
William Strieby, A.B., E.M. Professor of Metallurgy and Assaying, Colorado College, Colorado Springs, Col.
Bailey Willis, E.M., C.E., Geologist. In charge of Pacific Coast Division, North Trans-continental Survey. Address, Newport, R. I.

1879.

Nathaniel Lord Britton, E.M., Ph.D., Assistant in Geology, School of Mines. Columbia College, New York City.
Robert Bolton, Ph.B., Rock Hill Iron and Coal Co., Orbisonia, Huntingdon Co., Pa.
Leo George Cloud, A.B., E.M., Leadville, Col.
Harry Clay Cornwell, E.M., Mining Engineer, Nevadaville, Bald Mountain P. O., Gilpin Co., Col.
Louise Phillipe De Luze, C.E., 48 Pine Street, New York City.
George Spencer Eastwick, C.E., Manager of Sugar Refinery, New Orleans, La. Address, care of Havemeyer & Eastwick, Jersey City, N. J.
Louis Francis Haffen, A.M., C.E., Brewer, One Hundred and Fifty-second Street and Cortlandt Avenue, New York City,
Charles Sumner Harker, E.M. Address unknown.
Nathaniel Hathaway, Ph.B., Analytical Chemist, New Bedford, Mass.
Herman Hollerith, E.M., U. S. Patent Office, Washington, D. C.
Charles Arthur Hollick, Ph.B., box 105, New Brighton, S. I.
Isaac Bradley Johnson, E.M., Spuyten Duyvil, N. Y.
Robert Andrew Johnson, C.E., Assistant Sanitary Engineer, New York Board of Health. Address, Scarsdale, N. Y.
Edward Cabot Koch, E.M., 160 East Fifty-sixth Street, New York City.
Thomas Haight Leggett, Jr., E.M., Batopilas, State of Chihuahua, Mex.
Edwin Ludlow, E.M., Mineral R. R. & Mining Co., Shamokin, Pa.
Charles Wells Marsh, Ph.B., Student, Professor Hofmann's Laboratory, Berlin, Germany.

Theophilus Smith Mathis, E.M., Engineer of Mines and Deputy U. S. Mineral Surveyor, Telluride, Ouray Co., Col.
Ralph Edward Mayer, C.E., Assistant in Drawing, School of Mines, Columbia College, New York City.
Hubert John Merwin, E.M., Engineer, East Tennessee Iron and Coal Co., Knoxville, Tenn,
George Fanshaw Milliken, E.M., 120 Broadway, Room 27, New York City.
Otis Mortimer Munroe, Ph.B. Care of Tighe Electrical Light and Mfg. Co., 35 Water Street, Pittsburgh, Pa.
Knight Neftel, C.E., Ph.D., 32 Liberty Street, New York City.
James Nesmith, E.M., 256 Henry Street, Brooklyn, N. Y.
Charles Milton Noble, E.M., General Foreman, Woodstock Iron Works, Anniston, Ala.
Robert Dunn Rhodes, E.M., Mill Foreman, St. Helena Gold Mining Co., Las Delicias, Sonora, Mexico.
William Bell Stephen Reed, E.M. 171 St. Marks Ave., Brooklyn, L. I.
Francis Morris Rutherfurd, E.M., Assistant Supervisor Pennsylvania R. R., Bordentown, N. J.
Gardner Hutchinson Sheldon, E.M., Corralitos, Chihuahua, Mex.
George Cameron Stone, Ph.B., Chemist, New Jersey Zinc and Iron Co., Newark, N. J. Address, 127 Madison Avenue, New York City.
Henry Fowler Starr, Ph.B., Chemist, Newark Steel Works. Address, 91 Mount Pleasant Avenue, Newark, N. J.
* Francis Baretto Stewart, Ph.B. Died of Typhoid fever, at Harlem, New York, August, 1879.
John Richard Suydam, Jr., E.M., 43 East Twenty-second Street, New York City.
Granville Whittlesey Williams, E.M., 388 Clinton Street, Brooklyn, N. Y.

1880.

Alfred Lockwood Beebe, Ph.B., Fellow in Chemistry. Assistant Instructor in Assaying and General Chemistry, School of Mines, Columbia College. Residence, 58 East Sixty-eighth Street, New York City.
Frank Parkinson Benjamin, C.E. Address, 31 West Nineteenth Street, New York City.
Frederick Denison Browning, E.M. Chicago Sugar Refining Co., 75 Wabash Ave., Chicago, Ill. Address, care Ledoux & Ricketts, 10 Cedar Street, New York City.
William Frederic Brugmann, Ph.B., 327 East Fifty-seventh Street, New York City.
Nathaniel Butler, E.M. Care H. and U. Russell, 42 Barclay Street, New York City.
Alfred Daniel Churchill, A.M., M.S., E.M., Ph.D., Instructor in Drawing, School of Mines, Columbia College, New York City.
Edwin Perry Clark, E.M., 340 Clinton Street, Brooklyn, N. Y.
William Elliott, Ph.B., Chemist, Elliott, Hopke & Mattison, 197 Pearl Street, New York City.
Louis George Engel, E.M., Mining Engineer to Tilly Foster Iron Mine, Tilly Foster, N. Y.
Robert Otto Francke, C.E., traveling in Europe. Address, care D. O. Francke, Gothenburg, Sweden.
Herman Garlichs, E.M., Aurora Smelting and Refining Co., Aurora, Ill.
Wilkins Updike Greene, Ph.B., 38 South Portland Ave., Brooklyn, N. Y.
James Leal Greenleaf, C.E., Assistant in Engineering, School of Mines, Columbia College, New York City.
Albert Peter Hallock, Ph.D., Chemist, N. Y. Gaslight Co.; residence, 249 East Thirty-first Street, New York City.
Henry Harmon Hendricks, Ph.B., Hendricks Bros., 49 Cliff Street, New York; residence, 512 Fifth Avenue, New York City.
Louis Mosher Hooper, C.E., Elliot & Hooper, Consulting Sanitary Engineers, 252 Broadway, New York City.
Theodore M. Hopke, Ph.B., Chemist, Elliott, Hopke & Mattison, 197 Pearl Street, New York City; residence, Hastings-on-Hudson.
Edward Henry Hudson, C.E., Wholesale Coal Trade, Room 49, Trinity Building, 111 Broadway, New York City.

Frank Klepetko, E.M., Mining Engineer to Osceola and Tamarack Mining Companies. Address, Opechee P. O., Houghton County, Mich.

Wheaton Bradish Kunhardt, E.M., Engineer with the Bower-Barff Rustless Iron Co. of New York. Address, 24 Cliff Street, New York City.

Joseph Godley Mattison, Ph.B., Chemist, Elliott, Hopke & Mattison, 197 Pearl Street, New York City.

Charles August Meissner, Ph.B., Chemist, Briar Hall Iron and Coal Co. Address, Box 142, Briar Hill, Mahoning Co., O.

James Haviland Merritt, Ph.B., Chemist, Bradley White Lead Co., Water Street, New York; residence, 184 Lefferts Place, Brooklyn, N. Y.

Juan Adelberto Navarro, C.E., Commissioner of Mexican Government. Address, care Mexican Legation, Berlin, Germany.

Andrew McLean Parker, E.M., Ass't Engineer, Ferro Carril del Norte, Santo Tomas, Guatemala. Address, 37 William Street, New York City.

John Randolph Parks, E.M., Alma, Park Co., Colorado. Address, 39 Broadway, New York City.

Henry Alvord Robinson, Ph.B., Lawyer, with Robinson & Scribner, 102 Broadway, New York City; residence, 19 East Sixty-second Street, New York City.

Ferdinand Ruttmann, Jr., E.M., Churchill, Ruttmann & Parks, 39 Broadway, New York City.

George Singer, Jr., E.M. Address, care Singer, Nimmick & Co., Pittsburgh, Pa.

George Harton Singer, E.M., Singer, Nimmick & Co., Pittsburgh, Pa.

Wallace Augustus Smalley, E.M., Surveyor and Assayer, Silver City, N. Mex,

Maxwell Smith, C.E., Engineer, N. Y., W. S. & B. R. R. Address, 762 Madison Avenue, New York City.

Theodore Tonnelé, Ph.B. McKeesport Iron Co., McKeesport, Pa. City Address, 48 East Sixty-eighth Street, New York City.

Charles Herbert Torrey, Ph.B. Residence, 53 West One Hundred and Twenty-eighth Street, New York City.

Joseph Walker, Jr., C.E., 289 Fifth Avenue, New York City.

Herbert Allen Wheeler, E.M., Instructor, Washington University, St. Louis, Mo

1881.

Charles Alfred Andresen, E.M., with Pickard & Andresen, 8 Gold Street, New York City.

Frederic Theodor Aschman, Ph.B., Chemist. Wheeler Iron Company, P. O. Box 292, West Middlesex, Mercer County, Pa.

Chas. Popham Bleecker, E.M., Assayer Alice Gold and Silver Mining Co., Wallerville, Montana.

Victor Manuel Braschi, E.M., Ph.B., Resident Graduate ; candidate for degrees of C.E. and Ph.D. Address. care of Gogorzas Sons, 103 Front Street, New York City.

Edward Renshaw Bush, E.M. Address, care J. A. Bush, 54 Wall Street, New York City.

Philip Edward Chazal, A.B., E.M., Analytical Chemist, 46 Meeting Street, Charleston, S. C.

Albert Ladd Colby, Ph.B., Instructor in Quantitative Analysis, Lehigh University, South Bethlehem, Pa.

Edward Moorhouse Douglass, C.E. Topographer, U. S. Geological Survey. Address, Mechanicsville. Saratoga Co., N. Y.

Edward Kellogg Dunham, Ph.B., Student in Medicine, Harvard University. Address, 98 Boylston Street, Boston.

Arthur Henry Elliott, Ph.B., Assistant in Chemistry, College Physicians and Surgeons; also candidate for Ph.D., School of Mines. Address, School of Mines, New York City.

Howard Van Fleet Furman, E.M., Asst. Supt. Billings Smelting Works. P. O. Box 211, Socorro, New Mexico.

William Tudor Griswold, C.E., U. S. Geological Survey, Seventh and E Streets, Washington, D C.

Frederick Adolph Hemmer, Jr., Ph.B., Arminius Copper Mines, Tolersville, Va. Address, East Morrisania, New York City.

Chas. Breck Judd, E.M., United States Deputy Surveyor, Shakespeare, N. Mex.

Daniel James Leary, C.E., E.M. Address, 138 Keap Street, Brooklyn, N. Y.

Clement Le Boutillier, Ph.B., care of Le Boutillier Bros., 31 & 33 West Twenty-third Street, New York City.

Augustus Damon Ledoux, Ph.B., with Ledoux & Ricketts, 10 Cedar Street, New York City.
Willard Parker Little, E.M., Resident Graduate, Course in Architecture. Address, 60 West Fortieth Street, New York City.
Walter Monfort Meserole, C.E, N. Y., W. S. & B. R. R., Kingston, N. Y. Address, 590 Lorimer Street, Brooklyn, N. Y.
Percy Neyman, Ph.B., Resident Graduate. Address, care E. H. Neyman, 97 Maiden Lane, New York City.
Michael Joseph O'Connor, E.M., Resident Graduate, Course in Architecture. Address, 42 West Twenty-eighth Street, New York City.
Thomas Devlin O'Connor, Ph.B., Chemist, with Ledoux & Ricketts, 10 Cedar Street, N. Y. Residence, 42 West Twenty-eighth Street, New York City.
Lucius Pitkin, A.B., Ph.B., Chemist, Laurel Hill Chemical Works, Penny Bridge, L. I. Address, 432 Madison Ave., New York City.
George Sharp Raymer, A.B., E.M., Idaho Springs, Col. Address, 63 Seventh Avenue, Brooklyn, N. Y.
William Thomas Richmond, Ph.B., 68 Thomas Street, New York City.
Arthur Carr Roberts, E.M., 372 Broadway, New York City.
Chas. Pike Sawyer, Ph.B., Chemist, Whiting Manufacturing Co. Residence, 29 West Twenty-seventh Street, New York City.
William Waldemar Share, Ph. B., Tutor in Physics, Columbia College. Address, 336 Navy Street, Brooklyn, N. Y.
Chandler Dannat Starr, C.E., N. Y., W. S. & B. R. R., Lyons, N. Y.
Thomas Beale Stearns, E.M., Colorado Machinery Co., Denver, Col.
Alfred Ernest Swain, E.M. Address, 902 Prospect Street, Cleveland, Ohio.
Edgar Granger Tuttle, E.M., 92 Prospect Place, Brooklyn, N. Y.
Alvan Howard Van Sinderen, Ph.B., Lawyer, 45 William Street, New York. Residence, 178 Columbia Heights, Brooklyn, N. Y.
Herman Theodore Vulté, Ph.B., Fellow in Chemistry. Assistant Instructor in Qualitative Analysis and General Chemistry, School of Mines, Columbia College, New York City.
Ferdinand G. Wiechmann, Ph.D., Fellow in Chemistry. Assistant Instructor in Chemical Philosophy and General Chemistry, School of Mines, Columbia College, New York City.
William Fish Williams, C.E., E.M. Address, Wethersfield, Conn.
Herbert M. Wilson, C.E., Topographer, U. S. Geological Survey, Fort Wingate, New Mexico. Address, 26 Vesey Street, New York City.

1882.

Albert Calman, Ph.B., Student in Germany; care of Carlsbach & Cahn, Mayence a. R., Germany.
Thomas Peters Conant, E.M., with Thomas A. Edison. Address, care of Harper Bros., New York City.
William Hamilton Cooper, Ph.B., Constructing Engineer, 62 William Street, New York City.
Francis Bacon Crocker, E.M., Curtis & Crocker, 140 Nassau Street. Residence, 54 West Twenty-first Street, New York City.
Oscar Vincent Dougherty, Ph.B., with A. Dougherty, 80 Centre Street, New York. Address, 138 Columbia Heights, Brooklyn, N. Y.
Stancliff Bazen Downes, C.E., Office of Topographical Engineer, Dept. of Public Parks, Fifth Avenue and Sixty-fourth Street, New York. Address, 719 Lexington Avenue, New York City.
William Fletcher Downs, E.M., Supt. at Dixon Crucible Co., Jersey City, New Jersey.
Anton Frederick Emrich, E.M., care of A. Eilers. P. O. Box 8, South Pueblo, Col.
David Beauregard Falk, C.E. Address, care Falk, Hirsh & Co., Charleston, S. C.
Henry Feuchtwanger, Ph.B. Address, 64 East Sixty-fifth Street, New York City.
Charles Lincoln Fitch, E.M., Springfield Iron Co., Springfield, Ill.
Charles Buxton Going, Ph.B., Chemist, Cincinnati Desiccating Company, Cincinnati, Ohio. Address, Glendale, Ohio.
William Hill, C.E., with Collins Co., P. O. Box 196, Collinsville, Conn.
William Charles Illig, E.M., Park Department, New York. Address, 327 East Forty-first Street, New York City.
Cavalier Hargrave Jouet, Ph.B., Chemist, Ledoux & Ricketts, 10 Cedar Street, New York City.

Antonia Esteban Mesa, C.E., Sagua la Grande, Cuba.
Alfred Joseph Moses, E.M., Assistant in Mineralogy, School of Mines, Columbia College, New York City.
Edward Austin Oothout, E.M., Architect, 18 Broadway, New York City.
William Stevens Page, E.M., travelling in Europe. Address, 4 Trafalgar Square, London, England.
William Barclay Parsons, Jr., A.B., N. Y., L.E. & W. R. R., New Osborn House, Rochester, N. Y.
Clarence Quintard Payne, E.M., N.Y., W.S. & B. R.R., Weehawken Terminus, New Jersey. Address, 50 W. 24th Street, New York City.
John Bonsall Porter, E.M., licensed Instructor in Metallurgy, Cincinnati University. Address, Glendale, Ohio.
Cornelius Van Vorst Powers, Ph.B. Address, 22 West Forty-eight Street, New York City.
Ferdinand Sands, A.B., Ph.B., Chemist, with Prof. Potter, Washington University, St. Louis, Mo.
Willard Adams Shumway, A.M., E.M., U. S. Geological Survey, Washington, D. C.
William Field Staunton, Jr., E.M., Tombstone Mill and Mining Co., Tombstone, Arizona.
Nathaniel Strange Stockwell, E.M., Chicago, Ill. Address, Box 550, Orange, New Jersey.
Donald Butler Toucy, E.M., Student at Columbia Law School. Address, 43 West Fifty-third Street, New York City.
Frank Weiss Traphagen, Ph.D., Chemist, Williams, Clark & Co., Cotton Exchange New York City. Residence, Cartaret, N. J.
Rudolph Harrison Vondy, E.M., 489 Jersey Avenue, Jersey City, N. J.
John Howard Wainwright, Ph.B., Chemist, U. S. Laboratory, 402 Washington Street, New York City.
Albert George Wanier, Ph.B., care of Frederick Beck & Co., 206 West Twenty-ninth Street, New York City.
Norbert Reillieux Ward, E.M. Care of Walter McDermott, 2 Wall Street, New York City.
William Scherf White, E.M., Surveyor, 79 and 81 Cedar Street, New York City.
William Alexander Wilson, E.M., Box 153, Park City, Utah.
Charles August Wittmack, M.S., Ph.B., Student, Prof. Baeyer's Laboratory. Address, 40 Shilling St. III., München, Germany.
Edward Leavitt Young, E.M., Assistant Superintendent Little Annie Mining Co., Del Norte, Colorado.

1883.

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Class of 1867	13	Class of 1876	26
" 1868	20	" 1877	31
" 1869	11	" 1878	40
" 1870	9	" 1879	34
" 1871	7	" 1880	36
" 1872	5	" 1881	37
" 1873	5	" 1882	37
" 1874	9	" 1883	32
" 1875	20		

Total number of graduates.....372

Known to be deceased.

Class of 1868	Archibald MacMartin.
" 1869	Thomas Monahan Blossom.
" 1869	Henry Newton.
" 1872	Frank B. Jenney.
" 1875	Robert S. Lamson.
" 1877	Henry G. Clark.
" 1877	Frank S. Helleberg.
" 1877	James R. Priest.
" 1878	Owen F. Olmsted.
" 1878	Henry A. Hodges.
" 1879	Francis B. Stewart.
Total	11

Total number of graduates living..... 361

The list is corrected to Jany. 1, 1884.

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Secretary Alumni Association.

GRADUATES.—ALPHABETICAL LIST.

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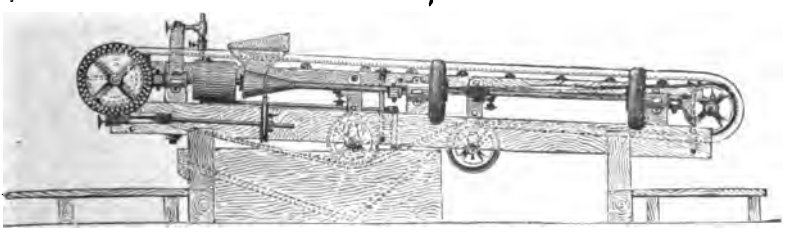

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THE

SCHOOL OF MINES QUARTERLY.

VOL. V. MARCH, 1884. No. 3.

THE METROLOGICAL SYSTEM OF THE GREAT PYRAMID.

(*Continued from page* 127.)

BY PRESIDENT F. A. P. BARNARD, LL.D., S.T.D.

THE article of the Pyramid faith which presents itself for examination next in order is the proposition that the height of the Pyramid is exactly one one-thousand millionth part of the mean distance of the Earth from the Sun. Inasmuch as we do not know the exact mean distance of the Earth from the Sun, it is impossible to subject this statement to the test of a rigorous comparison; but inasmuch as the builders of the Pyramid knew in all probability a great deal less about the matter than we do, it is next to impossible that the proposition should be true. Supposing it, however, for the sake of argument, to *be* true, the fact may be accounted for on either of two hypotheses—it is true accidentally, or it is true intentionally. Against the first of these hypotheses, the probabilities are in the proportion of infinity to zero; and this alternative, moreover, would be rejected with scorn by the disciples of the Pyramid religion. But that the fact may be true *in the intention of the builders*, as asserted, we must assume for them a knowledge which we have no reason to suppose them to have possessed. This slight difficulty the true believers dispose of summarily, by taking it for granted that their human ignorance was illuminated by direct

inspiration from on high. The orthodox doctrine on the subject, therefore, is that the true distance of the Sun was miraculously made known to the Pyramid architects, and therefore that the height of the structure itself was made not pretty nearly, but exactly, the one-thousand millionth part of that distance.

Now what are the facts on which this extraordinary assertion rests? Simply these: In 1867, Mr. William Petrie, having satisfied himself that the perimeter of the base of the pyramid "has been *proved* to symbolize a year, or the earth's annual revolution around the sun," and, further, "that the radius of that typical circle had also been shown to be the ancient vertical height of the Great Pyramid, the most important and unique line which can be drawn within the whole edifice," was moved by these weighty considerations to conclude that the same line "*must* represent also *the radius of the earth's mean orbit round the sun:* and in the proportion of 1 : 10^9, or 1 : 1,000,000,000: because, among other reasons, 10:9 is practically the shape of the Great Pyramid. For this building," he proceeds, "notwithstanding, or rather by virtue of, its angle at the *sides*, has practically and necessarily such another angle at the *corners*, that for every *ten* units its structure advances inward on the diagonal of the base, it practically rises upward, or *points to sunshine* by *nine*. Nine, too, out of the ten characteristic parts (viz., five angles and five sides) being the number of those parts which the sun shines on in such a shaped pyramid in such a latitude near the equator, out of a high sky." (*Our Inheritance in the Great Pyramid*, Edition of 1874, p. 48.)

This is the logic, and the whole of the logic, on the basis of which a fact is asserted which, to plain human reason and simple common sense, is so grotesquely improbable, that its possibility can only be defended by clothing it with the character of miracle. The true believers have not failed, accordingly, to be affected by a sort of painful misgiving lest this *a priori* argument should be found unsatisfactory to a skeptical world. They have therefore sought for a confirmation of their hypothesis in comparing the result furnished by it with those deduced from the most recent investigations of the solar parallax.

Since early in this century the mean distance of the sun has been generally taken to be about 95,000,000 miles. This value has been obtained from the parallax as computed by Encke at Altona, in 1822, with data derived from the transit

of Venus of 1769; a parallax which he found to be 8″.5776, giving for distance 95,454,000 British statute miles. In 1857, Prof. Airy proposed a new method for determining planetary distances, founded on displacements of Mars in right ascension, as observed morning and evening from a single station, when in opposition at its nearest approach to the earth. This method was applied in 1862, by observations made at Victoria, New South Wales, and by others made at the Royal Observatory, Greenwich, during the opposition of Mars in that year; and the results, as computed at Greenwich, gave a parallax of 8″.932, and a distance of 91,551,000 miles. In the mean time, Leverrier at Paris announced (in 1861) that in order to reconcile discrepancies in the theories of Venus, the Earth and Mars, it was necessary to assume a parallax approaching perhaps 8″.95. From this is obtained a solar distance of 91,357,000 miles. Chambers (Astronomy, p. 3) assumes as a probable value of the parallax, 8″.94, which gives 91,465,000 as the distance. On the other hand, Prof. Newcomb, in his Popular Astronomy says: "It would appear that the solar parallax must lie between pretty narrow limits, probably between 8″.82 and 8″.86; and that the distance of the sun in miles lies between 92,200,000 and 92,700,000 miles." Furthermore, Prof. Young in his recent book on the Sun, remarks: "It would seem that the solar parallax cannot differ much from 8″.80, though it may be as much as 0″.02 greater or smaller; this would correspond to a distance of 92,885,000 miles."

Besides the astronomical methods, of which there are others not here noticed, there is one of great scientific interest dependent on the velocity of light. The time required for a luminous impulse to reach the earth from the sun is known within about a second or less, so that if we can ascertain how far light travels in a single second, we are possessed of all the data necessary to secure a very close determination of the distance of the sun. Independent methods for the experimental solution of this problem were devised some years ago by Messrs. Fizeau and Foucault, of Paris; and one or the other of these methods has been repeated by Mr. Cornu in France, and by Lieut. Michelson of the U. S. Naval Academy at Annapolis. The results obtained by the experimenter last named, are regarded as very closely approaching to the exact truth. They give 299,900 kilometers as the velocity of light per second; and as light is 498 seconds in coming to us from the sun, we find the solar

distance to be 149,350,000 kilometers, equal to 92,803,464 miles. This nearly corresponds to a parallax of 8″.81 which would give a distance of 92,876,000 miles.

Now the distance of the Sun as worked out on the Pyramid theory is 91,837,000 miles. This is in the neighborhood of some of the astronomical determinations. It exceeds the lowest of them, and falls short of the highest. Prof. Smyth accordingly jumps, in this case as in many others in which a favorite quantity of his falls somewhere among several of the same class, directly to the conclusion that because his quantity is neither the smallest nor the largest, therefore it is the true one. But if we consider the judgments of astronomers as to these various determinations, we shall see that the inferior ones have no standing with them at all. Newcomb, our highest authority in this country upon physical astronomy, places the probable distance at about 92,500,000 miles, and Young puts it as high as 92,885,000; while the experiments on the velocity of light, which are esteemed to furnish the result most worthy of confidence, give a result almost identical with the estimate of Prof. Young. The Pyramid distance is, therefore, only about a million of miles too short; while, probably, the uncertainty which still attaches to scientific deductions is not so great as half a million.

But there is another consideration which is quite conclusive as to the question now under discussion. The pyramid is said to be, and appears to be really, a π pyramid. But in a π pyramid the height is equal to the perimeter of the base divided by $2\,\pi$. In such a pyramid, when the base is given, the height is inalterably fixed, and cannot have a value assigned to it at the caprice of the constructor. Now it is a doctrine vital to the pyramid religion that the side of the base shall contain the sacred cubit of the Hebrews as many times exactly as there are days, integral and fractional, in the tropical year. The height must, therefore, be that which this supposition demands, and it can be neither more nor less. On the other hand, if the height had been arbitrarily fixed at one one-thousand millionth part of the earth's mean distance from the Sun, the side of the base must have had a value such as *this* hypothesis requires; and could not have been determined by the cubit and the number of days in the year. It exceeds all the bounds of credibility, it exceeds all the powers of credulity, to suppose that two such entirely independent and inconsistent schemes

of construction should prove to be harmonious in their practical results. Such a coincidence is indeed physically possible, but the chance in favor of the possibility is less than one to some millions of infinites.

We have next to examine the pretension that the pyramid furnishes a measure, "in a round decimal number" of the daily progress of the earth in its orbit. Prof. Smyth introduces the announcement of this proposition in these magniloquent terms: "Already the Great Pyramid linear system—while still preserving its cubit reference by 10^7 to the Earth's polar axis—has yielded to the further researches of William Petrie the knowledge of a far grander reference yet in nature, and of a more comprehensive kind in science; but expressed in similarly round and even decimal repetitions of Pyramid numbers, and of Pyramid units of linear measure." (*Antiquity of Intellectual Man*, 1868, p. 258). Then, after drawing on our imaginations to conceive the terrific force but smooth uniformity with which this mighty globe, with its various and diversified freight, sweeps on through the vast fields of space, he continues: "And therewith comes the practical question, What given length of such path is swept over by the earth in that special period or standard for the measurement of time (so admirably uniform in itself, and so intensely important in ruling the affairs of men) as the interval represented by the whole earth turning upon its polar axis and bringing a day of toil and a night of rest to all the wearied nations of mankind. The answer is (as given by Mr. Petrie) if you employ Pyramid *units* or inches of linear measure, you may tell off that mighty standard of space and force in a round decimal number, or by 10^{7+4} *i.e.*, by 100,000,000,000 of Pyramid inches." Now what if it should appear that this wonderful discovery, announced with such a flourish of trumpets, is no new discovery at all; but is simply the reproduction, with a little change of form, of the absurdity we have just now disposed of? If it is true that the mean distance of the Sun from the Earth is one thousand million times the height of the Pyramid, and if it is at the same time true that the side of the Pyramid's base is 25 Pyramid inches multiplied by the number of days in the year, then the mean distance traveled daily by the Earth in its orbit must necessarily be exactly one hundred thousand millions of Pyramid inches; but if neither of these preliminary suppositions is true, or if both of them are false, the conclusion must be necessarily

false also. True or false, however, it is so directly dependent on the other propositions whose importance has already been so abundantly exploited and magnified by the disciples of the Pyramid faith, that it ought to have been regarded, even by them, as unworthy of a separate mention, instead of being heralded as it has been, as the grandest of all the properties yet brought to light in the miraculous structure of their worship.

The interdependence here asserted to exist between the propositions cited may thus be briefly shown. For the sake of conciseness we will employ symbols. Let h represent the height of the Pyramid; y, the numbers of days (integral and fractional) in the tropical year; r the mean radius of the Earth's orbit; and m the Earth's mean daily motion in its orbit.

Then $2\pi r$ is the circumference of the orbit, and the mean daily motion in the orbit is expressed by

$$m = \frac{2\pi r}{y} \qquad (1)$$

But we have already been instructed that the radius r is equal to the height h multiplied by 10^9, or that

$$r = h \times 10^9 \qquad (2)$$

Substitute this value of r for r itself in equation (1) and we have

$$m = \frac{2\pi h \times 10^9}{y} \qquad (3)$$

But we have also been told that the side of the base of the pyramid is equal to 25 Pyramid inches (the sacred cubit) multiplied by the number of days (integral and fractional) in the tropical year; and as there are four equal sides, the entire perimeter must be, therefore, equal to $100\,y$. And as this perimeter, is equal to the circumference of a circle of which h is the radius, it follows that

$$2\pi h = 100\,y \qquad (4)$$

Substitute now this value of $2\pi h$ for itself in equation (3) and we have

$$m = \frac{100y \times 10^9}{y} = 100 \times 10^9 = 10^{11};\ \text{Q. E. D.}$$

But, as we have shown that equation (2) cannot possibly be true, and that equation (4) is just as inadmissible, it is hardly necessary to add that the daily motion of the Earth in its orbit has not the remotest chance of being a "round and even decimal repetition of Pyramid units."

Of the pretension of the Pyramid theory which we are next to consider, viz., that which asserts that in the longitudinal dimensions of its passages we have a record (prophetic it must have been) of the most important epochs of human history, it is difficult to speak seriously. If we were dealing with periods of which authentic annals have come down to us, as of the capture of Constantinople or of the Declaration of American Independence, it would be easy to subject this pretension to an unimpeachable test. But of the three dates which are specified as distinctly indicated in this monument, viz., the dispersion of mankind at Babel, the Exodus of the Israelites from Egypt, and the birth of our Saviour, Jesus Christ; to which we may add a fourth—the date of the foundation of the Pyramid itself—there is not one which is not contested. Furthermore, while these dates are all unsettled as points in chronology, their asserted record in the structure is likewise uncertain; for the reason that, with the destruction by violence of the outer coating of the Pyramid, the initial point of reference has been removed, and can now only be reëstablished by a conjectural restoration.

That conjectural initial point, we are told, represents in chronology the dispersion of mankind at the confusion of tongues in the building of the tower of Babel. This event is placed by some chronologists at about one hundred years after the deluge, and by others as late as four hundred years after that catastrophe.

But the date of the deluge itself is one of the most uncertain in all archæology. Authorities differ in regard to it to the extent of more than a thousand years. According to the Masoretic Hebrew text of the Old Testament, the creation of the world took place 4161 years before the advent of Jesus Christ, and the deluge 1759 years later; that is in B.C. 2402. According to the Samaritan text, the creation was 4305 B.C., and the deluge 1708 A.M., which would fix this latter event at 2597 B.C. According to the Vatican Codex of the Septuagint, the numbers are 5270 for the Creation, and 2663 A.M. for the Deluge, carrying the drowning of the world back to 2607 B.C. And

according the Alexandrian Code, the year of the creation was 5508 B.C., the deluge being 2669 A.M., as before, removing the great flood still farther back to 2845. Petavius, a very learned chronologist of the seventeenth century, fixes on 2327 B.C. as the year of the Deluge; Archbishop Usher assigns the same event to 2348 B.C.; Hales to 3155 B.C.; and Jackson to 3170 B.C. The authors of the great work entitled *L'Art de Vérifier les Dates des Faits Historiques*, say that Noah went forth from the ark in the year 3307 B.C. Recent chronologists, however, are by no means content with even the largest of these numbers. The Chevalier von Bunsen, for example, puts the creation of Adam as far back as 20,000 B.C. and the birth of Noah at about 10,000 B.C. John Taylor adopts very nearly the chronology of Archbishop Usher, making the year 2349 instead of 2348. The difference is slight; but when we are considering a record of years said to be palpably recorded in inches of solid masonry, it is necessary to be particular. Prof. Smyth, who gives the date of the deluge only by implication, in giving, as we shall presently see, that of the dispersion from Babel, makes it somewhere between 2600 B.C. and 3000 B.C.

It is the date of the dispersion, however, which specially interests us at present; since that is the date which, in the religion of the Pyramid, is the initial chronological point at the mouth of the entrance passage. John Taylor puts this at 2247 B.C., and Professor Smyth at 2528 B.C. There is a rather startling discordance noticeable here between the disciple and the master, which tends seriously to shake our faith in the Chronology of the Pyramid. We must leave it for them to reconcile it between themselves, and in the mean time turn our attention to the testimony of non-Pyramidistic archæology.

There are naturally as many different dates assigned by different archæologists to the epoch of the dispersion as to that of the deluge. A few only need be cited in illustration here. The confusion of tongues is identified in time with the year of the birth of Peleg, a descendant in the fifth generation from Noah; and, according to the Alexandrian Codex of the Septuagint, Peleg was born in 2698 B.C. Archbishop Usher makes the date 2247. The authors of *L'Art de vérifier les Dates*, the most elaborate chronological work hitherto published, carry it back as far as 2907 B.C. These few citations may serve to show that what Professor Smyth loftily calls

"The Floor Roll of the World's Religious History" has not even an ascertained starting point.

The next point in this great "Floor Roll of Human History" is the date of the Exodus of the Israelites from Egypt. But here we meet with a discord among authorities no less bewildering than that which we have already encountered. The dates assigned by different chronologists to the event in question vary to the extent of nearly six hundred years. The work already cited, *L'Art de vérifier les Dates*, places it at 1865 B.C. Brugsch, Lepsius and Bunsen, however, from the more recent study of Egyptian History as revealed in the monuments, bring it down, the first to 1300 B.C., the second to 1312 B.C., and the third to somewhere between 1314 and 1320 B.C. Between these wide limits we have Usher, 1491 B.C.; Wilkinson, 1495 B.C.; Petavius, 1531 B.C.; Jackson, 1593 B.C.; the Septuagint, 1614 B.C.; Clinton, 1625 B.C.; and Hales, 1648 B.C. John Taylor does not give us a date for the Exodus, probably because the "Floor Roll of Human History" was a discovery of his school and not of himself. Nor does Professor Smyth give it with that exactitude which we have a right to expect of him in a matter of such moment. His statement of the date, and of the manner of finding it, is as follows: "Measuring along the passages backward from the north beginning of the Grand Gallery (the point assumed to mark the birth of our Saviour), you find the Exodus at either 1483 or 1542 B.C., and the dispersion of mankind at 2528 B.C. up at the beginning of the entrance passage." (*Our Inheritance in the Great Pyramid*, 1874, p. 390.) This duplication of dates for the Exodus comes from the fact that the first of the backward measurements given extends only to the roof of the entrance passage, while the second extends to the floor. The mean of these measurements, viz., 1512.5, presents a third value of the date, which we are presumably at liberty to choose. But no one of the three exactly corresponds to any of the determinations of the archæologists, though the first approximates that of Usher, and the second that of Petavius; and both of these, according to the most recent interpretations of Egyptian inscriptions, carry the event in question nearly two hundred years too far back. Brugsch has made it very clearly evident that the Pharaoh of the Exodus was Mineptah II., a monarch whose reign began in 1300 B.C., so that the Exodus itself must have been of some years later date. (*Brugsch's History of Egypt*

under the Pharaohs, 1881, vol. 2, p. 133.) We are compelled to conclude, therefore, that the "Floor Roll of Human History" can no more be relied on for the second of the important dates which are said to mark it, than it can be for the first.

As to the third of these dates, that of the birth of our Saviour—all archæologists agree that it is erroneously placed in the chronology generally accepted in these later centuries. In "*L'Art de vérifier les Dates*," the *Annunciation* is said to have taken place in the month of March of the 747th year after the foundation of Rome; in the second year of the 193d Olympiad; in the 39th of the reign of Augustus; in the 25th after the battle of Actium; and in the 35th after the elevation to power of Herod the Great. This places it nearly six years before the beginning of the Christian era as at present counted, and makes the epoch fall five years too late—a view now generally acquiesced in. Smith, in his Bible Dictionary shows us, however, that great diversity of opinion has prevailed on the subject. "For example," he remarks, "the birth of our Lord is placed in 1 B.C. by Pearson and Hug; in 2 B.C. by Scaliger; in 3 B.C. by Baronius, Calvisius, Süskind and Paulus; in 4 B.C. by Lamy, Bengel, Anger, Wieseler and Greswell; in 5 B.C. by Usher and Petavius; and in 7 B.C. by Ideler and Sanclemente. To this we may add the computation of Father Magnan, whose *Problema de Anno Nativitatis*, published in 1772, is cited by the authors of "*L'Art de vérifier les Dates*," and which places the nativity in B.C. 8. In the "Floor Roll of Human History," however, the epoch of the vulgar era is supposed to be correctly placed, and the beginning of the Grand Gallery marks the year 0.

But if the place of this epoch has been contested relatively to others—to the Olympiads, for instance, or to the A.U.C. of the Romans—still larger have been the differences of opinion, in referring it to its place in the great stream of time commencing at the creation. The authors of the elaborate work already quoted, on verifying dates, have brought together no fewer than one hundred and eight estimates by different chronologers of the place of the Incarnation in the world's history. Of these, the largest is that assumed in the Alphonsine Tables, edited A.D. 1782 by John Müller, otherwise called Regiomontanus, in which the birth of Christ is placed *Anno Mundi* 6984, and the smallest is that of L. Lippeman, Venice, 1554, which places the same event in A.M. 3616. The authors of the work

referred to, themselves adopt the date A.M. 4963. A table of different opinions as to this matter made by Hales, embraces one hundred and twenty different estimates; and Mr. George R. Gliddon (*Types of Mankind*, 1854, *Supplement*, p. 658) says that this number could easily be extended to three hundred.

While all prehistoric archæology is in a state so utterly unsettled and uncertain, it is impossible to conceive an assumption more wild or unwarranted than that which asserts that we have here, in a monument constructed by human hands, a record and measure of the intervals separating the most important events in human history, laid down in exact inches of length more, probably, than sixty centuries ago, and certainly not less than a thousand years before the events themselves had taken place. Let it also be borne in mind that this strange myth is a mere guess; that not a shadow of evidence has been produced to show that any such childish purpose was ever in the minds of the constructors of this monument as is here imputed to them. If they had designed to build so curious a riddle into the structure, is it conceivable that they would have left behind them no key to its solution—and not only no key, but no intimation, no slightest hint, that there was really here a riddle to be solved? Supposing, on the other hand, no riddle intended, but an open and outspoken prophetic history, is it conceivable that they could have failed to tell, in some manner which posterity could not mistake, where the prophecy was to be found, and by what law of interpretation it was to be brought to light? *A priori* there was quite as much reason to suppose the height of the pyramid to be a measure of time, as the length of its passages; and as much reason to suppose the length of a passage to be a measure of the distance of the sun, as that the height of the pyramid should be so. In other words, there is no reason *a priori* that either of these things should be true; and therefore there is every reason to feel assured that, if the builders of the pyramid had had any lesson whatever to convey to coming centuries by the dimensions or by the proportions of parts of the structure they were engaged in rearing at so vast a cost of labor and time and wealth, they would have clearly and distinctly declared the fact in some form as enduring as the monument itself. Upon the exterior surface of the finished pyramid, there was once, according to Herodotus, a legible inscription; but the same authority informs us that it was nothing but a silly statement of the vast

number of onions, radishes and cloves of garlic which had been consumed by the common workmen during the building. On its interior we know, from the testimony of all visitors, there has never been found in any place designed to be visited, a letter, a hieroglyphic or significant character of any kind; though the broad and smooth surfaces of its several chambers, its grand gallery and its marble finished passages, seem made for and to invite inscription. But they are all absolutely silent.

It is therefore an hypothesis utterly untenable to suppose that this monument embodies any lesson of either science or history or religion, built into it by the benevolence of the earlier centuries for the benefit of the later; or that the builders had any other object in view in heaping up this monstrous pile of stone, but the accomplishment of some purpose immediately interesting to themselves.

But the fact that the pyramid fails to tell its own story is no more remarkable than this other fact that, in all Egypt, there has never been found on any monument, either contemporary with it or of later date, in the form of incised or painted inscription, or even in any papyrus roll, any, the slightest, allusion to this object whatever; still less any single word to throw light upon the purpose of its erection. On the other hand, since it belongs to a class all the rest of which are unquestionably sepulchral, it is impossible to resist the conviction that this was sepulchral also, even if it was not designed for sepulchral purposes exclusively.

To return once more to "The Floor Roll of Human History," it may admitted that the fact that there is a coincidence between dates of certain signal events in the world's history and certain linear measurements in an artificial structure, is one which at first view is well fitted to excite the imagination, if not even to compel the belief that the coincidence cannot have been unintentional. But this impression loses much of its force after it has been discovered that the dates in question are all of them uncertain, and some of them so to the extent of several centuries: so that they are in fact practically unknown. Moreover, even if the dates were all perfectly well ascertained the effect of the noticed coincidences would be greatly shaken if it should be shown that such correspondences are by no means unique; but that by the study of chronological tables they may easily be paralleled. Of such parallels the following may serve as illustrations: We have seen that Prof. Smyth

places his earliest date, the confusion of tongues and the dispersion of mankind, at 2528 B.C. His intermediate point is determined by the intersection of the axis of the ascending passage with the roof or the axis or the floor of the entrance passage. The first intersection (which he assigns to the Exodus) would give a date of 1483 years B.C.; the second of 1512.5 B.C.; and the third of 1542 B.C. He has not distinctly pronounced in favor of any one of these dates, so that this point is left a little loose. The third great historical event presumed to be commemorated (foreshadowed, rather, from the builders' point of view) is the Advent.

Let us now take, on our own part, two dates of momentous interest, separated as nearly as possible by the same number of years which, according to Prof. Smyth, intervenes between the dispersion of mankind and the birth of our Saviour. We will choose for the earliest of these the foundation by King Solomon of the first temple at Jerusalem, an epoch commonly placed at 1013 B.C. For the other extreme we will elect the great religious movement known as the Reformation, which commenced in 1517 with the protest of Luther against the sale of indulgences by Tetzel. These two dates united give a sum of 2530 exceeding the extreme limits of Prof. Smyth by only the insignificant difference of two years. The Advent itself forms the intermediate term, and takes the place of the Exodus in Prof. Smyth's series; being within five units of the point defined by the intersection of the axes of the two passages of the Pyramid, which would give 1512.5 instead of 1517. Have we not, then, as much reason to believe that the Pyramid builders intended to foreshadow here the building of the temple and the Reformation of Luther, as that they designed to predict the confusion of tongues and the Exodus from Egypt?

As another example, let us take the three epochs: the giving of the tables of the Decalogue at Mt. Sinai; the compilation of the Old Testament Canon by Ezra; and the preaching of the first crusade by Peter the Hermit by order of Pope Urban II. This last event took place in A.D. 1094, and 2528 years counted backward from that date carry us to 1434 years B.C., which falls about midway between the dates assigned to the Exodus by different archæologists. Ezra is said to have settled the canon of the scripture about 448 B.C., and between this date and 1094 A.D. is an interval of 1542 years, which

corresponds to the date B.C. of Prof. Smyth's highest estimate for the Exodus. Thus we see that the Pyramid predicts to us very clearly not only the Exodus, but the reduction to systematic form of the inspired writings, and the commencement of the great series of religious wars waged for the recovery of the Holy Sepulchre.

Not to confine ourselves, however, to Hebrew or to religious archæology only, let us see if we cannot find coincidences equally striking elsewhere. In Græco-Roman history we have two signal events separated from one another by an interval of nearly 1500 years. The siege of Troy is an episode in the shadowy past, of which the date, like that of the dispersion of mankind, is uncertain between pretty large limits, and is generally ascribed, on conjectural grounds, to between 1100 and 1200 B.C. We will venture to take it at about 1075 B.C.; especially as, in all probability, the whole story is a myth. From this point of time onward to the downfall of the Eastern Empire, and the extinction of the last traces of Roman power, there is an interval of 2,528 years, which is exactly that required by Prof. Smyth's measurements from the mouth of the entrance passage onward to the beginning of the Grand Gallery. Also, between these two outside limits, we have the date of the battle of Actium, B.C. 30, which marks the beginning of the imperial form of government at Rome. This date added to 1453 gives a sum of 1483—exactly equal to the number of inches of the ascending passage of the pyramid, as measured back from the threshold of the Grand Gallery to the intersection with the roof of the entrance passage, which is one of the values of Prof. Smyth's later interval. Here, then, we have the Pyramid recording both the rise and the fall of the great Roman Empire.

Take again the following: The organization of the Roman State in its civil and religious institutions by Numa Pompilius dates at about 724 B.C. The accession to the imperial dignity of Constantine the Great took place in 306 A.D. Finally Napoleon Buonaparte was proclaimed Emperor of the French May 18, 1804. Between 724 B.C. and 1804 A.D. there is an nterval of 2528 years exactly, and the accession of Constantine falls 1498 years earlier than that of Napoleon, which number is between the limits 1483 and 1542 of Prof. Smyth. Thus the Pyramid predicts the accession to power of the first Chris tian emperor and of the greatest conqueror of modern times.

There remains to be considered the enigma presented by the mysterious "ruled lines," which Prof. Smyth has found on opposite sides of the entrance passage, at a distance of 2170 inches as measured backward from the beginning of the Grand Gallery. These lines, according to him, fix the date of the foundation of the Pyramid; a point of time which, by subtracting the foregoing date from 2528, we find to correspond with the 358th year after the dispersion of mankind at Babel. Now there is something extremely suggestive about this number 358. It is but a few units short of 365, the number of days in the tropical year. And as the original entrance mouth has long since disappeared, and can only be reëstablished by calculation or conjecture, the true place of that starting point may well be uncertain to the extent of seven or eight inches. The casing stones found by Col. Howard Vyse in 1837 at the foot of the northern slope were so large as to prove that the casing had been very thick; and it is quite possible that the mass of the pyramid beneath the casing may have been reduced when the casing itself was torn away, or later. This indeed, is quite possible in view of the enormous heaps of loose blocks which, not having been carried off by the destroyers, still encumber the foot of the monument on every side, as well as of the fact that the summit of the monument itself has been truncated to the extent of a twentieth part of its original height. One of the stones found in place by Col. Vyse measured more than eight feet along its base, at right angles to the Pyramid, and was no less than five feet in thickness. Prof. Smyth himself says that "the upper or northern end of the floor (of the entrance passage) is probably short by more than one hundred inches of the original surface of the Pyramid at that place." (*Life and Work at the Great Pyramid*, vol. 2, p. 37). He does not give us an account of how he established the true place of beginning, but he says that, in measuring backward from the entrance of the Grand Gallery we find "the dispersion of mankind in 2528 B.C. up at the beginning of the entrance passage." Now with a deficit to be supplied by doubtful calculation of, at any rate, "more than 100 inches," we may be justified in supposing that this number 2528 ought rather to be 2535, or perhaps 2535.2422, which would make the distance of Prof. Smyth's "ruled lines" downward from the entrance mouth just 365.2422 inches—that is to say, precisely as many inches as there are days (integral and fractional) in the tropical year. And there seems to be no

good reason why the tropical year should not be recorded in inches here as well as in cubits in the side of the base. This theory is submitted as furnishing an explanation of the "ruled lines" riddle, quite as plausible as that which finds in it a record of the date of the Pyramid itself.

In this case, as before, we can arrive at a variety of results equally remarkable by adopting other historical epochs for the starting point. For instance, Solomon, the greatest king of Israel, was born, according to Hales, 1030 B.C. From this date, if we take 358 years, we have 672 B.C., which is the year in which Manasseh, the fourteenth king of Judah, after having been carried off into captivity by Asaridinus, King of Babylon, was set at liberty and permitted to return to Jerusalem.

If we start from the foundation of Rome in 753 B.C. and count onward in like manner 358 years again, we shall fall on the year 395 B.C., the year in which the city of Veii was captured by the Romans after a ten-years siege; or if we count 365 years instead of 358, we shall come to a much more important event—the capture and burning of Rome by Brennus and his Gauls.

The exodus of the Israelites from Egypt is put by Brugsch at 1300 B.C. Just 358 years later, viz., in 942 B.C., occurred the great battle in the Valley of Zephathah, in which Asa, the third king of Judah, defeated Zerah the Ethiopian and his army of a million of men II. Chronicles xiv. 9) with an army greatly inferior.

The capture of Constantinople by Mahomet II, and the fall of the Eastern Empire, took place in 1453 A.D. If we count back from this date 358 years, we arrive at 1095 A.D., the year of the first Crusade.

The Diet of Worms assembled in 1545 A.D.; at 358 years earlier than that date, viz., 1187 A.D., Jerusalem was captured by the Saracen Sultan Saladin, after having been held by the Christians for nearly a century.

In 1850 A.D. California was admitted, as the thirty-first State, into the American Union. In 1492 A.D., 358 years before, America was discovered by Christopher Columbus.

These examples have been given merely for the purpose of showing how easy it is to find important dates in chronology to correspond to almost any series of two or three numbers taken at random; and therefore how little significance is to be attached to these measurements of the Pyramid's passages,

which have been dignified by the name of "The Floor Roll of Human Religious History."

We will pass now to a topic as to which the importance in the Pyramid faith has been still more highly magnified, viz., the sarcophagus, or as it is more respectfully called, the *coffer* of the King's Chamber. This object seems to have concentrated upon itself a more earnest attention, and to have secured to itself a deeper interest, than anything else connected with the Pyramid. It appears to be looked upon by true believers with something of the same kind of veneration with which the Israelites were accustomed to regard the ark of the Covenant.

The character of this vessel, in its present condition, is too obvious to be mistaken. It differs in no respect from other sarcophagi, except that it is without ornament or inscription. As has been already stated, one of its sides has been cut down nearly two inches, and the other three sides have been undercut to the same level, evidently in order to allow a lid to be placed over it by sliding laterally. Moreover, as in other sarcophagi, there are holes, three in number, each about an inch in diameter, bored downward from the upper surface of the side which has been cut away, the purpose of which was to allow strong wooden pins, placed loosely in corresponding holes in the lid, to drop into them when the lid is pushed home to its place, so as to prevent removal by sliding, while the dovetail undercutting prevents removal by lifting. These peculiarities sufficiently indicate the purpose for which this object was constructed, and to simple common sense would seem to leave room for no further question in regard to its character. But simple common sense is not the quality for which our friends of the Pyramid persuasion are most remarkable. To them, this stone box had a more lofty design than that of receiving the body of any mortal man, however great or powerful. It is the visible embodiment of a divine message to men, prescribing to them the system of weights and measures by which they are bound to be governed in their dealings with one another. Primarily, it is a standard of capacity; but secondarily, it becomes a standard of weight likewise; and more indirectly still, a standard of length. Moreover, its capacity as a standard, must be understood of the capacity which belonged to it before it received those modifications which give it, at present, the appearance of a sarcophagus. In other words, in its original construction, all its sides were of equal height, and none of them

were cut away in whole or in part. In that condition it constituted a measure of the unit of capacity from which all other measures were to be derived. The modification and mutilation of its form, which have thrown so much obscurity over its original design, are assumed to be outrages committed by sacrilegious hands in later but unascertained times. In corroboration of this view, it is remarked that the vessel, though prepared to receive a lid, has never had a lid since the time of its discovery in A.D. 820, by Al Mamoun; and that a sarcophagus without a lid is not a sarcophagus. The argument may be taken for what it is worth; but it seems to be attended with one or two slight difficulties, among which are the following:

1. Nobody knows what Al Mamoun found in the Pyramid, but all the world knows what he hoped to find, and that was treasure. If he found, as he probably did, the sarcophagus covered by a lid, he could hardly have failed to believe that within it lay concealed, not the body of the monarch only, but his jewels also. Nothing could be more natural than that he should seek to satisfy at once his curiosity and his cupidity by violating the sanctity of the tomb. But he could not remove the lid by either lifting or sliding. He therefore broke it, and the fragments of it have long since been carried away by the myriads of curious visitors who, during the more than one thousand years that have since elapsed, have successively penetrated into this mysterious vault.

2. Suppose that Al Mamoun found no lid; he did not cut down the coffer itself from its original form to the shape in which we find it at present. The undertaking would have been no slight one, for the material of the vessel is a compact syenitic granite, so tough that the knocks and bangings of hundreds of thousands of tourists, eager to secure splinters as mementos, have, after all, inflicted upon it no very serious damage, except at one corner. He could have had no motive for meddling with it, but every motive for getting away as fast as possible; for his men, worn out by their long and fruitless labor, were becoming disaffected to such a degree that he is said to have resorted to a ruse to content them, by secretly burying among the rubbish a treasure which they were at length permitted to discover and to share.

3. The alteration in the form of the coffer cannot have been made after the closing of the Pyramid by its builders, and before Al Mamoun's time; for, though there is reason to believe

that the entrance was discovered and that the interior had been visited at some early day, there is equal reason for supposing that such visitation was for destructive and not for constructive purposes.

4. The design of the builders was, unquestionably, to conceal the entrance, and the means they employed for this purpose were so effectual that, even after it had been found by the intruders just referred to, and closed by them a second time, it remained so difficult of detection that not the slightest suspicion of its existence was entertained by Al Mamoun, when he undertook and accomplished an entrance by violence. It is, moreover, not by any means certain that the King's Chamber was ever reached by any visitor before Al Mamoun, and if it was, it was hardly so more than once; so that little opportunity could have been found for making any changes there after the time of the builders. There is consequently the best reason for believing that the coffer, or sarcophagus, is at this day in the same condition in which it came from their hands, with the exception of the injuries it has suffered at the hands of modern tourists.

The difficulty of resisting the evidence that this object has existed in its present actual form from the beginning, is so great, that Prof. Piazzi Smyth actually concedes the point, though somewhat ungraciously, as follows: "I am quite ready to allow it (the coffer) to be 'a blind sarcophagus,' viz.: a *deceiving blind* to the eyes of the profane Egyptian workmen, as well as a symbol sarcophagus to others, reminding them of death, judgment, and eternity (as well taught by William Simpson, artist), but without therefore interfering one iota with its farther more exact objects and intentions." (*Our Inheritance in the Great Pyramid*, 1874, p. 142.)

There is, in this passage, an innocent unconsciousness on the part of the professor, of the inconsistency, not to say dishonesty, imputed to the designers of the mysterious pyramid coffer, which is truly amusing. Their "exact object and intention" was to make manifest to men the will of God as to the measures they should use in their daily intercourse with each other, by the construction of a type and standard of such measures to be copied and employed by them; but their *act* was to place before men "a deceiving blind," adapted to remind them, not of bargaining and selling, but of "death, judgment, and eternity." This same imputation of inconsistency between

purpose and act, ascribed to the builders, appears as well in the writings of John Taylor as in those of Prof. Smyth. Mr. Taylor has the following curious paragraph (we quote from "*Our Inheritance*," etc., p. 98, not having found the passage in place in Mr. Taylor's book): "The quarter corn measures of the British farmer are fourth parts or quarters of the contents of the coffer in the King's Chamber of the Great Pyramid; and the same pyramid's name, instead of being descended from *πῦρ, fire*, may rather have been derived from *πυρός, wheat*, and *μέτρον, measure*, signifying a measure of wheat. To establish the groundwork of an international standard to that end, *though not at that time to publish it generally*, would seem to have been a leading purpose of the Great Pyramid ages ago; and the true value in size of its particular measure has not sensibly deteriorated during all the varied revolutions of society in the last 4,040 years." How far this last assertion is sustained by the facts will presently be examined.

Since, therefore, it is admitted that this vessel of which the character has been so laboriously discussed, and of which the metrological purpose is so hotly insisted on, has never had any other figure than that which it has now, the injuries by recent violence excepted, we should have a right to expect that, taken as a measure of capacity, it should be taken for what it will hold now, or rather what it would have held when originally shut up uninjured in its finished form in the heart of the Pyramid. But this is not the doctrine preached to us by the disciples of the Pyramid faith. The coffer, they say, as a standard of capacity, must have the parts which have been cut away in giving it the form of a sarcophagus, restored, so that all its sides shall be equal in height and in thickness. With this understanding it ceases to be an actual present standard, but becomes merely an ideal standard. It is not an instrumentality for ascertaining experimentally the quantity of matter which constitutes an unit of bulk; but it affords the means of calculating what that unit ought to be. The elements entering into that calculation have been furnished by means of measurements made by many explorers, and especially by Prof. Smyth himself, who has devoted to this inquiry an immense amount of painstaking labor. The several dimensions so ascertained, when expressed in English inches, seem to be connected with each other by no clear law of relation, nor are they improved in this respect when converted into what Prof. Smyth calls

Pyramid inches; but John Taylor has found that, when expressed in *digits*, a digit being the twenty-fourth part of a royal cubit of 20.736 British inches, the interior length is, or was apparently meant to be, 90 digits, the breadth 30 digits, and the depth 40 digits.

The contents, as computed by Prof. Smyth according to different methods, which it is hardly worth while to repeat, vary from a little above to a little below 71,250 cubic Pyramid inches, which are equivalent to 71,464 cubic British inches. Now the cube of the double cubit of Karnak (41.472 inches) is 71,328.8 cubic inches; so that Mr. Taylor's inference that it was the design of the constructor of the coffer to give it the capacity of a double cubit cubed seems to have a foundation of probability. But this simple solution of a very simple problem is by no means satisfactory to Prof. Smyth. He discovers a much more recondite origin for this particular number. His method involves the use, it is true, of two uncertain quantities; and perhaps it may be regarded as evidence of a too fastidiously critical mind to remark that such elements are out of place in fixing a standard of absolute accuracy. These elements are, first, the polar axis of the earth, which, as we have seen, is still a subject of controversy, and secondly, the earth's mean density, which is more unsettled still. Prof. Smyth's proposition is this: Multiply the tenth part of the cube of the ten-millionth part of the earth's polar diameter by the mean density of the earth, and the product will give the Pyramid unit of capacity—that is to say, the contents of the coffer as it was before it was cut down into a sarcophagus. Now the ten-millionth part of the polar diameter of the earth is held, by the disciples of the Pyramid religion, as we have seen, to be a double sacred cubit, equal to 50 Pyramid inches, or 50.05 British inches. And by trial we shall find that $\frac{1}{10} \times 50^3 \times 5.7 = 71{,}250$ cubic Pyramid inches, and that $\frac{1}{10} \times 50.05^3 \times 5.7 = 71{,}464$ cubic British inches. The arithmetical coincidence is exact: but we shall see that this extremely satisfactory result is only owing to the happy selection of a value for the axis of the earth which no computer has ever found, and of a number expressive of the earth's density which no investigator of that subject has ever reached. The question of the earth's axis we have already considered. Let us attend for a moment to the other. The density of the earth is a very difficult subject of investigation. It has been sought by three methods: 1. By observing the effect of the lateral attraction

of a mountain upon the direction of the plumb-line—a method employed by Maskelyne, and by Col. Sir Henry James; 2. By measuring the amount of torsion produced by bringing heavy leaden balls near the small balls of a delicate torsion-balance—the method of Cavendish, repeated by Reich and Baily; and 3, by comparing the relative numbers of diurnal oscillations of the same pendulum at the earth's surface and in deep mines—the method of Prof. Airy. The results obtained by the different experimenters have been widely different. Maskelyne inferred a density of 4.71; James, a density of 5.316; Cavendish, 5.32; Baily, 5.66; Reich, 5.58; and Airy, 6.56. Supposing all these determinations to be of equal weight, the probabilities would favor their mean, which is 5.524. But they are not of equal weight; and though the name of Airy is a great one, the practical difficulties in the way of applying his method place his results among the least reliable. From a careful study of this question more than ten years ago, the present writer was led to the conclusion that the mean density of the earth cannot differ far from 5.6. Prof. Newcomb says: "Of these results that of Baily is probably the best, and the most probable mean density of the earth is about 5⅔ times that of water." But if we use Baily's mean density 5.66, we shall obtain, by Prof. Smyth's process, only 70,750 cubic Pyramid inches for the contents of the coffer—a value which will never answer. And if, instead of 50.05 British inches as the ten-millionth part of the earth's polar axis, we take the mean of the last five computations of that axis, which we have already given, and employ the ten-millionth part of this, viz., 49.273 British inches, along with Baily's density, in Prof. Smyth's formula, the totally discouraging result is arrived at of 67,865 cubic British inches.

The *rationale* of Professor Smyth's process, of which it is almost sad to see here the disgraceful breakdown, seems to be the following: In the Pyramid metrology, the passage from the linear base (in this case, the sacred cubit) to the system of derivative measures, is not first, as is usual, to a measure of liquid capacity, but to an unit of solid capacity; neither is it to a solid, or vessel, having the usual form and magnitude of a cube of the linear base; but to a magnitude described as the tenth part of the cube of a double unit. This solid unit is supposed also to have a density equal to the mean density of the earth, so that if its volume is multiplied by the numerical

index of the earth's specific gravity, the product will be the volume of a body of water having the same weight as the solid. And the volume of water thus obtained becomes in its turn the standard of the entire system.

It is impossible to believe, without evidence of the most positive and conclusive description, that a plan so complicated, so contrary to all metrological usage elsewhere, and, we may add, so singularly illogical, can ever have originated among any people; and yet here we are called upon to impute such a plan to a people who lived six thousand years ago, and of whom we have not a single fact, or a single line of record, to tell that they ever made a study of metrology at all.

The theory of the coffer by Professor Smyth seems to require no further attention. Let us now turn to the question how far Mr. Taylor's statement is capable of being maintained, viz., that the capacity of the coffer is the original unit of corn-measure, from which the measures still existing in Great Britain under the names of the *quarter* and the *bushel* have been derived; and that "the true value in size of its (the coffer's) particular measure has not sensibly deteriorated during all the varied revolutions of society in the last 4,040 years."

The British quarter, Mr. Taylor tells us, is the fourth part of an unit now obsolete, equivalent in capacity to the coffer, and which was called the *chaldron*. He even gives us the etymology of this name, deriving it from *caldarium*, the Roman warm bath; in allusion to the form of the coffer, which resembles a bathing-tub. How the Romans should have known the form of this vessel, which was shut up out of their sight until several hundred years after the fall of the Western Empire, or how they should have recognized it as a standard if they had seen it, since Professor Smyth tells us that it was intended as "a deceiving blind," not to be recognized, does not appear. Let that matter pass. What we have to inquire now is whether it is true that the present British corn-measures are measures originally derived from the coffer of the Pyramid; and how far it is true that, through such measures, the standard furnished by the coffer has been maintained without sensible variation for four thousand years.

We have no clear history of British weights and measures going back farther than about six hundred and fifty years (9 Henry III, A.D. 1225), though it is believed that the yard was determined in 1101 from the length of the arm of King

Henry I. The earliest statute on the subject founded the whole system of British metrology upon the weight of the silver penny, which it required to be equal to that of "thirty-two wheat corns taken from the middle of the ear," the succession being that "twenty pennyweights do make an ounce; and twelve ounces one pound; and eight pounds do make a gallon of wine; and eight gallons of wine do make a London bushel, which is the eighth part of a quarter." If this quarter was the fourth part of the capacity of the Pyramid coffer, the king and his council seem not to have been aware of the fact. But was it? The thirty-two wheat corns were equal to 22½ grains Troy, and the bushel computed from these data had the capacity of 1691.52 cubic inches. From this we compute the quarter to have been equal to 13,532.16 cubic inches, and the chaldron, or assumed equivalent of the coffer, 54,128.64. Mr. John Quincy Adams, however (*Report to U. S. House of Rep.*, Feb. 22, 1820), says that in 1304 there was in actual use in England a wheat gallon of 264½ cubic inches, giving a bushel of 2,114⅔ cubic inches, from which we derive a quarter of 16,917⅓ cubic inches, and a chaldron of 67,669⅓ cubic inches.

In the reign of Henry VI, we find, A.D. 1423, a bushel of 2,148.24 cubic inches, afterward, with a very slight alteration, called the *Winchester bushel*. This gives a quarter of 17,185.92 cubic inches and a chaldron of 68,743.68 cubic inches.

Near the close of the same century (12 Henry VII, A.D. 1496) the bushel was reduced to such a degree that the people refused to use it. It was made 1,792 cubic inches, giving a quarter of 14,336 cubic inches, and a chaldron of 57,344 cubic inches.

During the same reign there came into use, somewhat irregularly, a bushel of 2,224 cubic inches, from which we may calculate a quarter of 17,792 cubic inches, and a chaldron of 71,168 cubic inches.

By a statute of Henry VIII (23 Henry VIII, A.D. 1531) a gallon was established of 282 cubic inches, giving a bushel of 2,256 cubic inches, a quarter of 18,048 cubic inches and a chaldron of 72,192 cubic inches.

In the year 1701 (13 William III) the Winchester bushel was reëstablished as the standard; but the bushel measure representing it found at the Exchequer proved to be too small, and the statute therefore explicitly defined the capacity of this measure, declaring that the standard bushel should be a cylin-

drical vessel 18½ inches in diameter and 8 inches deep. This statute was reënacted in the following reign (5 Anne, A.D. 1706), and the bushel, computed according to the terms of the act, contained about two cubic inches more than it had done originally, under the statute of Henry III. It was now 2150.42 cubic inches, from which we derive a quarter of 17,203.36 cubic inches, and a chaldron of 68,813.44 cubic inches.

Finally, in 1824 (4 George IV), it was enacted that the gallon measure shall be a vessel capable of containing "ten pounds avoirdupois, or 70,000 grains Troy, of distilled water at the temperature of 62° F., weighed by brass weights under the barometric pressure of thirty inches;" the volumetric capacity being at the same time stated at 277.274 cubic inches, from which it is seen that the bushel becomes 2218.192 cubic inches, the quarter 17,745.536 cubic inches, and the chaldron 70,982.144 cubic inches.

This brief outline of the history of British legislation on the subject of weights and measures will serve to show how completely independent it has been of the metrology of former centuries, and how entirely controlled by the immediate circumstances and needs of the British people. The earliest British corn-measure was based on the natural though imperfect standard of a definite number of wheat corns taken by weight. And the standard which for four centuries, ending in 1824, was generally prevalent in the British islands, and which continues still to be standard in the United States, gives a chaldron more than 2,500 cubic inches less than the capacity of the Pyramid coffer. In view of these facts, to say that this coffer has been the standard from which the corn-measures of Great Britain have been derived, and from which there has been no material variation for forty centuries, is one of so surprising a character as almost to argue lunacy in the man who makes it.

(To be continued.)

MANGANESE IN SLAGS FORMED BY ARGENTIFEROUS LEAD-SMELTING.

By MALVERN W. ILES, Ph.D.

A LITTLE over two years ago my attention was directed to a consideration of the rôle manganese plays in slags, by a few remarks of Mr. A. Eilers in the columns of *The Engineer*-

ing and Mining Journal (see April, 1881). Mr. Eilers there states: "At our works at Salt Lake City it was a rare occurrence to find any lead or silver in the slag which I made there of almost the same chemical composition that we use here [Leadville]. The only difference is that here a few per cent. MnO enter the slag. Whether the too easy fusibility of the $2MnO, SiO_2$, and the consequent rising of the 'smelting zone' (as encroaching on 'the zone of production'), is the cause, I have not definitely settled."

Before proceeding farther, I will state that my object in quoting the above is not to engender a discussion on this subject, but merely to point out the fact that the influence of manganese in argentiferous lead slags has been imperfectly understood, and furthermore, the literature on this subject is so meagre that metallurgists have been almost groping in the dark.

If "at Salt Lake City it was a rare occurrence to find *any* lead or silver in the slag," then I made up my mind that the composition of such a slag was of the greatest moment. I am prepared to state I have never yet found a slag, produced either by myself or any one else, which did not yield at least a trace of lead or silver; and I have never yet found a slag that showed at the same time traces of silver and lead, although I have examined a score of slags purporting to be barren in these metals.

Since 1881 I have assayed and analyzed, and had others to test, a great many slags—some with almost no manganese, and others in which manganese was the largest base present, and I have come to the conclusion that instead of manganese causing losses in silver, it more often aids to prevent this loss. Furthermore, I have made upon several occasions large mixtures, varying from 1,200 to 1,800 tons, in which an unusually large amount of manganese was present, and I have not noticed that manganese has had the slightest tendency to cause what is generally known as "overfire," or "fire-tops."

Whenever moderate quantities of manganese are present in ores to be smelted, I think it should be figured on exactly the same as iron in making up the charge, and when present to any considerable extent, it would be well to make a certain allowance for its fluidity and the property it has of making even silicious slags fluid; since manganese has an enormous absorbent power for silicic acid. When there is a somewhat un-

usual amount, give to manganese a greater power than iron in the charge calculations.

While we think manganese is a positive benefit in the lead-silver industry, yet it must be handled with proper care and discretion, since we can add too much of any of the ingredients constituting a charge. In fact, I know of one case in this State where, by simply neglecting altogether the subject of manganese, the slag carried the ruinous amount of from 8 to 10 per cent. lead. Yet with the same ores the slag can be and was made to run from ½ to 1½ per cent. lead; which goes to prove that we are, perhaps, correct in our surmises on the subject of manganese.

Prof. John A. Church has recently favored me with several manganiferous slags, produced at the Harshaw Works, Tombstone, Arizona. These slags have been examined by Mr. Walter T. Page, a careful and accurate analyst, with the following results:

		SiO_2	29.60 per cent.
Sp. Gr.	3.73	FeO	11.56 "
		Al_2O_3	6.34 "
		MnO	43.25 "
		CaO	7.50 "
			98.25

This slag gave by fire-assay $1\frac{4}{10}$ per cent. of lead, and only by the greatest care did it show a *trace* of silver. These samples were particularly free from both matte and speiss, and were markedly crystalline, showing large columnar prisms; and had a markedly low fusing point. Thin fragments showed an amethystine hue. There are some highly manganiferous slags which are exceedingly friable, almost granular in texture which are very bad slags indeed. We think that the fault cannot be attributed to manganese, but simply to an improper slag composition; as, for example, allowing the silicic acid to drop too low.

I cannot but regard the composition of the first-mentioned slag as possessing the highest scientific interest, and a valuable acquisition to the literature on manganese slags.

Prof. Church informs me that the result of a large number of assays showed the silver to be less than 1½ ounces per ton in the slag, and generally under ½ ounce. The samples in m possession confirm this statement. I might remark, in passing, that I regard a correct fire-assay on slags as perhaps the most

difficult operation the assayer is called upon to perform, and I am satisfied that while a great many assayers have not the slightest idea of misrepresentation, yet they often report slags as containing only traces of lead or silver, and that the same slag placed in the hands of more careful assayers will show very startling results. I know of several metallurgists who were allowed to pass peaceful nights from this cause.

Several prominent metallurgists have stated to me, that during their experience they have invariably found manganese to cause losses in silver; and I will not positively deny this statement. At the same time I raise the question: Is it not possible that these losses were due to an incorrect charge?—perhaps an abnormal working of the furnace? Or perhaps there was not a proper admixture of fuel; in short, there may have been a number of causes which might have given rise to these losses; and we, not being able to locate exactly the difficulty, immediately ascribe the evil effects to manganese.

The idea seems to be prevalent that in all ores where the manganese exists as a di-oxide, silver losses are more apt to occur; and the reasons generally ascribed are much as follows:

At a comparatively low temperature MnO_2 parts with an atom of oxygen, which unites with silver, forming an oxide (Ag_2O), and inasmuch as this oxide is a powerful base, it in turn unites with silica, and is thereby carried off into the slag as a silicate. Now, while this idea is somewhat fascinating and beautiful in theory, yet I maintain that there are circumstances or conditions in which this is not necessarily the case.

I have nearly always found that if such a slag be very carefully analyzed and we add together the percentages of iron and manganese, that these united bases will be an improper percentage for the amount of silica contained in the slag.

All metallurgists and chemists connected with metallurgical works in this industry fully appreciate the difficulty of keeping an accurate account of the manganese existing in the ores to be smelted. How easy it is for an ore containing from 5 to 10 per cent. of manganese to enter the smelting mixture without any note being taken thereof! I am satisfied that when more care is directed to these determinations, there will be less complaints that slags running high in silver is due to manganese.

To return to the idea that pyrolusite causes an oxidation of silver, thereby occasioning silver losses, I will state that I have a whole suite of ores which produced the Harshaw slag,

and that the manganese generally exists as a di-oxide in these ores. It therefore appears exceedingly strange that, with so large a percentage of manganese, we should have such minute losses in silver. The bullion produced at these works is generally high grade, therefore we cannot say that this small loss was due to very low grade bullion.

Others, also, have examined this slag with practically the same results as stated above; and I have only recently been informed by Mr. Furman, late chemist to the Germania Works, that he found large percentages of manganese and a very small amount of silver in the slag, viz., less than one ounce per ton.

As for the nascent oxygen given off from the oxides of manganese, and oxidizing silver, I think this idea is somewhat hasty. We are taught that there are three oxides of silver, namely: Ag_2O, Ag_4O and Ag_2O_2—but only one of them, Ag_2O, can be regarded as a well-defined compound. Hence if any oxide is formed let us suppose it to be the one best and generally known (or Ag_2O).

Fownes states this oxide to be decomposed at a red heat, giving rise to metallic silver and nascent oxygen; while Adolph Wurtz says the decomposition is effected at a temperature *below* 100° C. Therefore, it appears strange that there should be an oxide formed at all, since we know the temperature is such that the compound would be immediately decomposed. I do not wish it to be understood that I question the formation of silicate of silver, or that it is not sometimes present in slags; since experiments were made in Dr. Percy's laboratory, clearly demonstrating the formation of this compound; and Plattner plainly states that some slags contain silicate of silver. But, to ascribe the formation of silicate of silver, and silver losses in general, to the rôle of manganese, I regard as wholly illogical and without just cause, viewed either from a metallurgical or chemical standpoint.

Aside from the advantage manganese possesses in causing a large amount of silica to be fluxed off, and also of largely increasing tonnage, we would specially direct attention to the fact that in cases where zinc ores are treated, manganese causes much of this metal to enter the slag, and in some cases a very large amount. Such an example was mentioned by Prof. Pierce before the Am. Inst. of Mining Engineers, convened at Denver, Col.

In treating manganiferous ores, I regard the percentage of lime entering the slag to be of the utmost moment. While the amount of lime we think is very largely dependent upon the iron and silica ratio, it is also dependent upon the amount of manganese. Where the slag contains from 2½ to 4 per cent. Mn, we do not regard it, as a general rule, advisable to make a slag carrying more than 15 to 20 per cent. CaO. In treating exceedingly silicious ores, or where there is much alumina present, this statement is subject to limitation. Many careful observations have led me to the idea that as the manganese increases the lime should be decreased, and the converse of this statement we regard as true.

In order to illustrate this latter statement, we will give the analysis of another Harshaw manganiferous slag as follows:

SiO_2	33.00
FeO	14.22
Al_2O_3	4.20
MnO	25.78
CaO	13.10
MgO	1.00
	91.30

The other constitutents, as S + PbO + alkalies, etc., were not quantitatively determined. This slag was also quite good so far as silver and lead losses are concerned. Fire assay gave ½ oz. silver per ton and one per cent. lead. It will be noted that while in the first analysis given, there was only 7½ per cent. CaO, in the analysis just cited we have 13.10 per cent. CaO, but the amount of manganese in these cases has materially changed.

In view of the above facts, I am led to the statement *a priori*, that I see no reason why the metallurgist cannot do just as good smelting with pure pyrolusite as with pure limonite, so far as the fluxing of silica is concerned.

Certainly there might be cases in which iron would be better, and more widely applicable; also the presence of certain elements as zinc, arsenic, antimony and sulphur, might play an exceedingly peculiar rôle, under these peculiar circumstances. In the case of sulphur ores, one might ask, what would become of the sulphur? We would not get a sulphide of manganese matte, certainly. Would the sulphur be eliminated as sulphurous acid?—would there be an increased tendency to form lead matte? As no one has ever, I think, tried the experi-

ment, it would be difficult to answer these questions, which are of great technical importance.

It is my firm belief that as the percentage of manganese increases in the smelting mixture, the amount of matte diminishes, and that by having a very large amount of manganese we would get little or no matte, and only a comparatively small amount of arsenical speiss.

It is well known to some of the western smelters that lime very materially diminishes the production of iron matte.[1] I have never been able to understand why there should be such a wide-spread dislike to manganese for smelting. During my experience I have found no single objection to this metal—on the contrary many great advantages, some of which I have endeavored to enumerate above.

In conclusion, I will give briefly the mode of estimating manganese at these works:

Manganese Scheme (Volumetric). Take ½ to 1 gram of the finely powdered substance (ore or slag) according to the amount of manganese present, and treat in a casserole with HCl (conc.) with the addition of a small amount of HNO_3. Then boil, and add H_2SO_4, gradually replacing *all* the HCl + HNO_3—or until fumes of SO_3. Dilute the cooled mass to about 150 c.c. and boil. Now add an emulsion of ZnO in large excess, filter off $SiO_2 + ZnO + Fe(OH)_3$, etc.

Dilute up to ½ litre. Draw off from this an aliquot part, say 100 c.c., transfer to casserole, and heat to boiling and titrate with a known strength of $KMnO_4$ (Normal recommended). Titration performed directly in a casserole, with the liquid a trifle below boiling point, with vigorous stirring until there is a faint rose tint.

Calculate the percentage of iron corresponding to the $KMnO_4$ used, and multiply this percentage found by 0.2946= Mn.

The above method is perhaps the best yet devised for manganese determinations, and is rapidly performed.

[1] See Mr. Schneider's article on lime slags, read before the Am. Inst. of Mining Engineers.

GASES CONTAINED IN STEEL.[1]

TRANSLATED BY PROF. T. EGLESTON, PH.D.

DR. MULLER has recently been making some interesting experiments at Bochum, on the gases contained in steel. These were: 1. Gas collected from the ingot moulds at the moment of casting; 2. Gas obtained by piercing the cold ingot.

1. To collect the gas during the casting, Dr. Muller selected a mould containing 285 kilos., closed at the top, but fitted with an iron tube. At the end of this tube, a glass tube 8 mm. in diameter, with a bulb 50 c.c., blown out in the centre, was fitted. When the mould was full, the gas escaped and completely filled the bulb and the pipe, at the end of which it could be lighted. When the operation has continued long enough to exclude all the air, both ends of the tube are closed with wax, and are immediately soldered by a blowpipe.

This method was found inconvenient, and was afterward used only for Thomas steel. It was superseded by the following: An ordinary mould is filled from the top to a certain distance; the rest is then filled with calcined powdered quartz, and the opening closed with a cover luted with clay. In the centre of this cover, the tube with the bulb is placed.

The sand has not only the advantage of excluding the air, but it cools the gas enough to prevent its taking fire. The assay sample was considered a correct one when the gas took fire at the end of the tube but the flames did not enter it. In the analyses, those designated "above" were taken in this way, and those designated "below" were taken by the former method.

The sealed bulbs are carried to the laboratory, where the gases are transferred to the eudiometer by adapting to the two slender parts of the bulb two rubber tubes, each receiving a glass tube, the rubber being bent, and filled with mercury, and the rest being filled with it afterward and arranged upon the mercury trough. This done, the small ends of the bulb in the interior of the rubber are broken. Mercury is poured into the end by a funnel, and the gas passes into the eudiometer. If the analysis shows oxygen it comes from the atmosphere, and

[1] From the Comptes Rendus Mensuels de la Soc. de l'Industrie Minérale. Sept. and Oct., 1883.

it is necessary to deduct it and a volume four times as great for the nitrogen.

This correction is made to bring the composition to 100. When collecting the gas in the mould by the first method, part of the oxygen may be burned, so that no calculation can be made of the quantity of nitrogen.

Gas from Cast Iron.

The metal was taken from the opening of the Bessemer cupolas; the mould contained 60 kilos.

I. Gray Bessemer Iron. The casting gives off a great deal of gas. The fracture is gray, fine-grained and without blow-holes. The ingot is covered with a white coating 1 mm. thick.

The Cast Iron Contained,		The Gas Contained,	
Combined carbon	0.584	Carbonic oxide	37.3
Graphite	3.104	Hydrogen	58.3
Silicium	1.680	Nitrogen	0.5
Manganese	1.930	Carbonic acid	3.9

II. Spiegel. Gives off a quantity of gas. Ingot without blow-holes. Fracture laminated.

Cast Iron.		Gas.	
Carbon	4.180	Carbonic oxide	8.7
Silicium	0.253	Hydrogen	49.5
Manganese	7.370	Nitrogen	0.5
		Carbonic acid	1.3

III. Cast iron for basic Bessemer. Gives off less gas than the preceding. Ingot without blow-holes. Fracture radiated.

Cast Iron.		Gas.	
Carbon	3.099	Carbonic oxide	39.6
Silicium	0.203	Hydrogen	46.8
Phosphorus	3.025	Nitrogen	10
Manganese	0.736	Carbonic acid	3.6

There is little diversity in the gas from these cast irons of such different characters, and this is not surprising, since when liquid they act alike, the differences not being evident till they become solid. Compare the results with those obtained from working on the solid castings.

From a cast iron heated to redness in a vacuum.		From a gray cast iron cold—Dr. Muller.
Troost & Hautefeuille, Gray cast iron.	Mr. Parry, White cast iron.	Average of five assays.
Carbonic oxide.....16.76	2.3	3.5
Hydrogen.....70.07	84.0	73.9
Nitrogen..... ....5.98	6.9	22.6
Carbonic acid..... 3.59	6.8	Working under water.

These show that CO is formed more abundantly during solidification than hydrogen or nitrogen, which have greater affinity for the metal. These gases are not the results of reactions which take place in the ingot mould, but were simply dissolved in the metal. As some of these cast irons contained considerable silicon and still gave off an amount of CO, the conclusion must be drawn that at the temperature of fusion of thin cast iron (1150°) silicon does not reduce CO, and as the affinity of oxygen for carbon increases with the temperature, the reaction probably does not take place except at a much higher temperature.

Gases from Acid Bessemer.

The cast iron used contains a medium amount of silicon and manganese, and is cast very hot from the cupolas. The carbon commences to diminish at once, the first half of the silicon is burned rapidly, and then this combustion stops, to go on very rapidly at the end, when the carbon has disappeared, and is then accompanied by the combustion of the manganese. The slags are fluid and contain a great deal of silicate of manganese. The recarburation with spiegel is accompanied by a violent disengagement of oxide of carbon. A great deal of flame is produced during the operation of turning the steel into the ladle. While being cast into the moulds the metal is quiet and the ingots have no blow-holes, but give off gas from the upper part during the solidification.

Steel for springs gives off more gas than softer steel for rails. The metal contains:

	4. *Steel for Rails.*			5, 6, 7. *Steel for Springs.*		
Carbon	0.23	to	0.28	0.48	to	0.53
Manganese	.50	"	.60	.80	"	.90
Silicon	.15	"	.25	.15	"	.25
Phosphorus	.06	"	.08	.06	"	.08

The gas contains:

	4. *1st Method.*	5. *2d Method.*	6. *2d Method.*	7. *1st Method.*
Carbonic Oxide	37.3	34.	41.7	45.9
Hydrogen	47.3	49.5	19.1	41.4
Nitrogen	7.9	8.6	37.9	9.9
Carbonic Acid	7.5	7.9	0.4	2.8
Oxygen	0.0	0.0	0.7	0.0

In order to ascertain whether the composition of the gas underwent any change while it remained in the ladle, the gas from the first and last ingot from the same ladle was analyzed and found to contain :

8. STEEL FOR RAILS WITHOUT BLOW-HOLES.		9. STEEL FOR SPRINGS WITHOUT BLOW-HOLES.	
First ingot cast.	Last ingot cast 17 minutes after first.	First ingot cast.	Last ingot cast 24 minutes after first.
Carbonic oxide. 38.7	43.4	48.2	42.5
Hydrogen..... 51.3	46.9	44.5	36.5
Nitrogen..... 7.2	6.6	2.5	17.1
Carbonic acid.. 2.8	3.1	4.8	3.7

It is seen that the last ingots gave off least carbonic oxide and a little less hydrogen. As during the entire time of casting the steel was quite tranquil in the ladle, without the disengagement of any gas, it is probable that the gaseous elements of the metal had not varied very much. The abnormal proportion of oxygen in No. 9 should therefore come from the air. These assays apply to steels giving ingots without blow-holes. It was desirable to ascertain whether the gas from ingots with blow-holes has the same composition. It is only exceptionally that ingots with blow-holes are produced at Bochum, and this only takes place when the working is less hot during the operation and its end, and the quantity of silicon has a tendency to increase in the upper part of the ingot. The assays made under these conditions have given—

No. 10. Steel having a feeble tendency to rise and kept down by sprinkling the top of the ingot.

No. 11. Steel rising sufficiently rapid to make it necessary to wedge down the cover of the ingot mould.

No. 12. Steel which rises rapidly and boils a great deal.

	10.	11.	12.	12.[1] Gas collected by Mr. Stead from an ingot cast by first method in England.
Carbonic oxide.....	38.4	31.5	70.7	12.5
Hydrogen.....	51.	39.2	20.7	82.5
Nitrogen.....	2.2	21.6	6.5	5.
Carbonic acid.....	8.4	7.7	2.1	0

It is seen that the composition of the gases which are given off from the steel with blow-holes differs little from those of cast iron or of steels giving sound ingots. In No. 11 the composition of the gas approaches that which was previously found from the basic process.

The difference between the steels with blow-holes and those without might come from the quantity of gas, and Dr. Muller endeavored to ascertain what this quantity was. The gases collected by Mr. Stead contain a great deal less carbonic oxide. At the end of the Bessemer operation, before the addition of spiegel there remains but a very small quantity of carbon. The oxygen from the air which is blown in can no longer form carbonic oxide, and it is mostly nitrogen which traverses the bath. It was interesting to see what would be the gas dissolved in the metal under these conditions. A small ladle was filled before recarburation and cast. The ingots contain a quantity of vermicular blow-holes near the circumference and some rounded blow-holes in the interior. The steel boiled and rose in the ingot mould. Two successive assays, 13 and 14, were made.

	13—Top *1st Method.*	14—Top *1st Method.*
Carbonic oxide	18.6	18.1
Hydrogen	54.2	52.9
Nitrogen	24.9	26.8
Carbonic acid	2.3	2.2

As could have been foreseen, the proportion of carbonic oxide was diminished a good deal, while that of nitrogen increased. As might have been expected the metal which was taken in this way before the addition of spiegel was very rotten. When a complete decarburation takes place in the Martin process an equally rotten material is obtained, two successive assays of gas from which gave the following results.

	15.	16.
Carbonic oxide	48.0	46.1
Hydrogen	35.1	43.6
Nitrogen	15.4	6.9
Carbonic acid	1.5	3.4

It is seen that the proportion of carbonic oxide is much greater, and that of the nitrogen less than in 13 and 14. This is owing to the fact that the scoria which covers the bath in the furnace prevents the absorption of the hydrogen and the

nitrogen of the flame, while the slow oxidation of the carbon in contact with the scoria contained is favorable to the saturation of the bath with carbonic oxide.

Gases from Basic Bessemer.

These have attracted from the very outset the attention of Dr. Muller. The reaction of the spiegel in the converter is relatively feeble, the addition of ferro-manganese producing almost no disengagement of carbonic oxide, while on the contrary in the ladle there was a large quantity of flame. When the steel has become quiet in the ladle, the boiling and the explosions recommence in the ingot mould. Notwithstanding this abundant disengagement of gas, the tendency of the steel to rise and to form blow-holes is not great at Bochum, and the ingots are quite sound even for the steel which has boiled the most. The following analyses are of soft Thomas steel deoxidized and recarburized by the addition of two per cent. of ferro-manganese, containing a large per cent. of manganese. The steel contains:

Carbon	0.05	to	0.10
Silicon	traces		
Phosphorus	0.05	to	0.1
Manganese	0.45	to	0.55

The gas contains:

	17.	18.	19.	20.	21.	22.	Average.
Carbonic oxide	61.3	57.5	76.6	57.7	50.9	77.3	65.
Hydrogen	2.3	4.7	6.1	4.8	5.1	6.4	5.
Nitrogen	36.4	38.0	17.3	30.5	43.3	16.0	30.
Carbonic acid	0.0	0.0	0.0	0.0	0.3	0.4	——

The basic steel for rails recarburized with melted spiegel and only differing from the above steel by having .25 of carbon, gave:

	23.
Carbonic oxide	68.
Hydrogen	16.2
Nitrogen	11.0
Carbonic acid	4.8

Another charge of basic steel for rails, which was terminated by the addition of ten per cent. of spiegel gave off a great deal of flame; the steel boiled and rose rapidly in the ingot mould. The gas from the fourth ingot was taken, and nine

minutes later that from the last; the analyses gave the compositions below:

	24.	25.
Carbonic oxide	56.5	62.0
Hydrogen	33.0	34.2
Nitrogen	8.6	1.0
Carbonic acid	1.9	2.8

While the metal was still liquid in the ingot mould, the basic steel gave a rapid disengagement of gas, which diminished as soon as the steel commenced to grow cold. It was found interesting to compare the composition of the gases of these two periods; for this, in the same casting of soft steel, there were collected first, the gases of the first ingot 26*a* cast in the first method, as soon as the ingot mould was full, 26*b* cast by the second method without filling with quartzose sand and without putting on the cover until the steel was solid. The same operation was carried out for 27 *a* and *b*, which was rail steel. The following are the results:

	26. Soft Steel.		27. Steel for Rails.	
	a.	*b.*	*a.*	*b.*
Carbonic oxide	77.9	62.6	81.7	54.1
Hydrogen	5.7	12.6	8.2	38.6
Nitrogen	14.7	23.2	9.5	3.5
Carbonic acid	1.7	1.6	0.6	3.8

These experiments seem to prove that the first gases which are given off, and cause the basic steel to boil, are almost exclusively oxide of carbon. On the contrary, as soon as the steel commences to solidify, the composition of the gases is only that given by the acid Bessemer. It results from what has preceded that the violent boiling which characterizes the Thomas steel is principally due to the disengagement of carbonic oxide, which distinguishes the Thomas steel from the Martin, acid Bessemer, and from cast iron. It may be asked how far the carbonic oxide comes from the fining of the cast iron or from the reaction after the addition of spiegel. At Bochum the assays made at the end of a basic operation are not alike. Sometimes the steel is still and gives a small ingot which is entirely sound, but at other times it explodes and boils without there being any apparent reason for the difference. However if the over-blow is not pushed too far so as

not to reduce the quantity of phosphorus below .15 per cent., the steel of the assay sample is tranquil and rises very little. In general it may be said that the steel before the addition of spiegel is more tranquil than the finished steel. In order to clear up this question, Mr. Muller collected the gas from two ingots (28 and 29) of Thomas steel before the addition of spiegel. For the first the bath was relatively tranquil. For the second, two consecutive assays were made on the same ingot, the steel containing a great deal of gas.

28. *1st Method.*	29. *2d Method.*	
	a.	*b.*
Carbonic oxide..... 8.8	27.3	35.
Hydrogen 71.9	43.5	38.4
Nitrogen 18.2	26.2	22.5
Carbonic acid..... 2.0	3.0	4.1

It results from these analyses that the composition of the basic Bessemer before the addition of the spiegel may be considered as in the category of the Martin and acid Bessemer. The large proportion of carbonic oxide which the Thomas steel contains after the addition of spiegel appears to come from the reaction, and the carbonic oxide formed intermolecularly remains dissolved during a certain time until it collects in sufficiently large bubbles to disengage itself. Mr. Muller insists upon this point, and cites the reasons why this delay in the disengagement of carbonic oxide cannot be attributed to a tardy reaction coming from an imperfect mixture. He thinks that the temperature of the steel plays an important rôle in hindering or hastening the disengagement of the carbonic oxide. Dr. Muller then tried to explain the rôle of the silicon added to a basic steel. These investigations are not yet terminated. The first addition to the converter of five per cent. of a melted silicious cast iron containing 14 per cent. of silicon gave a steel entirely tranquil in the ladle and in the ingot. This steel rose nevertheless, and the ingot contained vermicular blow-holes. (See No. 4, of gas collected by piercing cold.)

The attempt to collect gas at the time of casting failed. On the other hand, the silicon acted on the scoria of the converter, re-introducing phosphorus, which gave a fragile steel. Another attempt was made with the addition of 5 per cent. of the same silicious cast iron, and 2½ per cent. of ferro-manga-

nese, containing 70 per cent. of manganese (see 3 of the gas collected cold). The steel remained tranquil, but rose in the ingot moulds.

Analyses show that the yield in phosphorus increased from .106 to .515, while there remained but .011 of silicon in the bath. Two samples of gas were taken, one, *a*, from a small ingot mould at the commencement of the casting, and the other, *b*, from a larger ingot mould at the end of the casting. They gave:

30.	*a.*	*b.*
Carbonic oxide	64.6	44.1
Hydrogen	18.9	41.6
Nitrogen	14.4	10.6
Carbonic acid	2.1	3.7

In order to diminish the re-absorption of the phosphorus, the same additions as above, five per cent. of silicious cast iron and two per cent of ferro-manganese were made in another operation; only, instead of putting them melted into the converter, they were heated to redness and put into the ladle at the moment of turning down. The gas acted just as before. These experiments have a double interest. The analyses of the gas and the metal were both made. The metal contained:

	Before Addition.	After Addition.	Mixture Before Reaction.
Carbon	0.002	0.115	0.14
Silicon	0.002	0.162	0.530
Manganese	0.083	0.944	1.250
Phosphorus	0.078	0.097	....

The reaction acted especially on the silicon and carbon and on the manganese. The re-phosphorization was very small. The steel cast in the ingot moulds rose slowly and gave off very little gas. The analyses made on the two different ingot moulds gave for the gas:

31.	*a.*	*b.*
Carbonic oxide	34.7	30.8
Hydrogen	58.7	65.8
Nitrogen	4.1	1.9
Carbonic acid	3.2	1.5

As might be seen, the proportion of carbonic oxide and of hydrogen approach that of the Thomas steel before the addition (see 29), but the proportion of nitrogen is much less.

Gas from the Cold Thomas Steel.

2. After these experiments on the composition of gas that

came off from liquid metal, it was natural to ask what would be the composition of the gas which would be obtained from the basic metal when cold. In order to make these assays Dr. Mulller used the same process which he had used previously, employing only a hollowed drill which gave a continuous shaving, in order to disengage, especially, the gas of the blow-holes, and not the intermolecular gas. A soft basic Bessemer which exploded and boiled, rising moderately in the ingot mould, with the addition at the end of the operation of 2½ per cent. of ferro-manganese which contained 35 per cent. of manganese, gave on piercing cold, 36 per cent. of gas, composed as follows:

	a.		*b.*	
Carbonic oxide	0.6		0.4	
Hydrogen	85.4	36 per cent. gas.	64.5	20 per cent. gas.
Nitrogen	14.3		35.4	

The ingot showed a large number of radiated blow-holes. Thomas steel without addition did not boil, either in the ladle or in the ingot mould, exploded a little, and rose slowly; there were a small number of radiated blow-holes in the ingot.

The steel of analysis 30, deoxidized, and re-carburized with 5 per cent. of silicious cast iron with 14 per cent. of silicon, and 2½ per cent. of ferro-manganese containing 70 per cent. of manganese. The steel was motionless and slowly rose in the ingot mould. The ingot had a small number of blow-holes.

ANALYSES.

	III.		IV.	
Carbonic oxide	0.4		0.0	
Hydrogen	86.4	22 per cent. gas.	54.7	6 per cent. gas.
Nitrogen	12.7		45.3	

The basic steel spoken of above with five per cent. of silicious cast iron. The steel rose slowly in the ingot mould; the ingot contained only a small number of blow-holes. (See IV.)

These results accord with those which Dr. Muller obtained previously by the same process, and confirm the observations already made, that the proportion of nitrogen increases as the total quantity of gas diminishes. The author proposes to discuss these results later more carefully. In the meantime he insists upon the distinction to be made between the explosions and the boiling of liquid steel on the one side, and the rising of the steel in the ingot mould on the other. There are steels which explode and, nevertheless, give sound ingots. There are others which are entirely still in the liquid condition, but

which, however, give blown ingots and rise in the ingot mould while they are becoming solid. Other steels show the two phenomena of boiling and of rising at the same time, and there are those which do not explode, nor boil, nor rise. The explosion of steel appears to be attributed to the disengagement of carbonic oxide, which, having no affinity for the metal, disengages itself rapidly, and the rising of the metal in the ingot mould is caused more by gases, namely, hydrogen or nitrogen, which, having more affinity for the steel, are only disengaged when the steel is already too pasty to allow them to rise to the surface. The addition of the manganese products for the deoxidation gives rise to a disengagement of carbonic oxide. On adding the silicious cast iron, the reaction, on the contrary, is produced without the production of gas. The liquid steel is tranquil, but nevertheless rises in the ingot mould.

To sum up, it is seen according to the experiments here noted that in gas collected in the ingot moulds hydrogen is found and predominates except in the recarburized Thomas steels where carbonic oxide is the principal gas. We may expect, therefore, to find at least 30 per cent. of carbonic oxide in the Thomas steel when it has been collected cold. But these experiments give but a very small portion of the carbonic oxide, so that one would be tempted to admit a reabsorption of the gas if one did not know that steel at a bright red heat absorbs hydrogen in preference to carbonic oxide. It must be admitted, as has been said above, that all the carbonic oxide is given off before solidification of the metal, and it is for this reason that the cold metal does not contain any. But in order that we may accept this explanation as fact, it would be necessary to prove that carbonic oxide was never found in cold steel. But in experiments made in a vacuum there have been found in iron and soft steel, besides the hydrogen, considerable quantities of carbonic oxide, and Mr. Stead analyzing the gas from the Giers casting pits has found two parts of carbonic oxide for three of hydrogen. It is for this reason that the preceding explanation does not completely satisfy the author, who is disposed to compare the formation of the vermicular blowholes to the separation of the graphite which takes place in gray or mottled cast iron as it becomes solid. The hydrogen and nitrogen, he says, ought to be considered as combined with the metal exactly in the same way as the carbon or the phosphorus, if not entirely, at least in part. These two gases

are driven out at the moment of solidification in the same condition as the graphite in cast iron. It is for this reason that we only find after cooling generally hydrogen and nitrogen in the blow-holes, and that on the other side the quantity of blow-holes varies for the same metal according to the physical condition of the cast iron, just as is the case for graphite.

Mr. Brustlein considered the researches of Dr. Muller as a methodical step toward the solution of this complicated question. These are the results of a large number of conscientious observations which can be used as a basis for forming an opinion. Without entering upon a critical analysis, which requires much reflection, he thinks it well to recall some of the conclusions reached by Messrs. Troost and Hautefeuille, in their remarkable work on the solubility of different gases in cast iron, steel and iron. The silicon diminishes the solubility of hydrogen in cast iron in fusion. Manganese increases it very considerably. Cast iron and steel dissolve more hydrogen than carbonic oxide, and retain the first more thoroughly than the second. Soft iron, on the contrary, dissolves more carbonic oxide than hydrogen, and the former is more energetically retained. Manganese diminishes the solubility of carbonic oxide, and even prevents it entirely. Mr. Brustlein thinks that these facts may find some applications to the reactions of the basic Bessemer, and aid in explaining the gas phenomena which takes place there. He adds that in breaking the ingots cold, the presence of ammonia, or, at least, of a gas soluble in water, and giving strong alkaline reactions, has been established by careful observation.

ON THE WRITING OF CHEMICAL EQUATIONS.

By F. G. WIECHMANN, Ph.D.

THE proper constructing of chemical equations, though certainly a matter of considerable interest and importance to every student of chemical science, has not as yet, in general, met with that share of attention which its importance warrants. A few words in this connection will hence not prove amiss, and a brief consideration of various methods adopted, may be not without interest.

Before, however, proceeding to the subject proper, it will be necessary to consider briefly chemical symbols and chemical formulæ.

A *chemical symbol* is the abbreviated designation of an element representing at the same time the definite proportion by weight in which the element will enter into combination.

Thus, the symbol of chlorine is Cl; the atomic weight of chlorine is 35.5. Hence the symbol Cl is not only an abbreviated expression of the name of the element, but is to suggest as well the atomic weight of that element—namely, 35.5.

The degree of the power that elements have of holding other elements in combination with themselves, is termed their quantivalence or atomicity.

The quantivalence of some elements is one, of others two, three, four, five, six, seven, and of some even eight. All elements whose quantivalence is expressed by an odd number are called perissads, those whose quantivalence is expressed by an even number—artiads. Thus, the elements possessing one, three, five or seven bonds are classed as perissads; they are termed respectively, monads, triads, pentads and heptads. Those having two, four, six or eight bonds are artiads, and are termed dyads, tetrads, hexads and octads.

A *chemical formula* is the expression in symbols of the chemical constitution of a body.

An *empirical* formula is the simplest expression of the ratio in which the elements composing the substance are present, e. g.: Empirical formula of acetic acid; CH_2O.

A *molecular* formula shows the absolute number of atoms of each of the elements combining to form the molecule, as well as the mere numerical ratio between them, e. g.: Molecular formula of acetic acid; $C_2H_4O_2$.

The molecular formula may, and often does, coincide with the empirical formula; if not, it must be some simple multiple of the latter.

A formula conveys three distinct ideas. It illustrates:

1st. A qualitative relation.

2d. A quantitative relation by weight.

3d. A quantitative relation by gaseous volume.

Thus the formula NH_3 shows:

1st. That NH_3 is a combination of N and H.

2d. That NH_3 consists of fourteen parts by weight of N, and three parts by weight of H.

3d. That one volume of N gas combines with three volumes of H to form two volumes of NH_3.

A *chemical equation* is the expression in symbols or formulæ of the changes that elements or compounds undergo when subjected to chemical, or, in some instances, to physical influences. As matter is indestructible, these expressions of change must of necessity be equations, for, whatever the change, nothing is lost.

Three kinds of chemical equations may be distinguished: synthetical, analytical and metathetical.

Synthetical equations are those representing the union of elements or of compounds:

$2H+O=H_2O$.

$2KCl+PtCl_4=K_2PtCl_6$.

Analytical equations illustrate the separation of a compound into its constituents:

$CaCO_3+heat=CaO+CO_2$.

Metathetical equations demonstrate the interchange of elements or of radicals, and the formation of new products:

$$BaCl_2 + H_2SO_4 = BaSO_4 + 2HCl.$$

Metathetical equations—or, as they are also called, equations of interchange—claim attention most frequently, and among these, equations of oxidation and reduction present the most interesting problems.[1]

The laws governing chemical interchange have not yet been fully determined, but it is found that two conditions exert an important bearing on the result.[2]

1st. Whenever a compound can be formed, which is insoluble in the menstruum present, this compound separates as a precipitate.[3]

2d. Whenever a gas can be formed, or any substance which is volatile at the temperature at which the experiment is made, this volatile product is set free.

The law of interchange may also be stated to be, in general terms: the tendency to form the compounds developing the highest thermal effects.

Furthermore the interchange effected is always on terms regulated by the quantivalence of the elements or radicals in-

[1] Equations of oxidation and reduction are, however, not always metathetical equations.

[2] Cooke: "Principles of Chemical Philosophy," p. 55.

[3] This, however, is not invariably the case.

volved. This is to say that a monad element or radical can replace another monad element or radical atom by atom; that a dyad element or radical can replace another dyad element or radical atom by atom; that, however, to effect a similar exchange, two of a monad element or radical are needed, and so on.

Bearing then in mind these points, to write an equation of interchange, the following simple suggestions may be followed.

1st. Place down as first member of the equation the symbols or formulæ of the substances entering into the reaction, and place the plus sign between them.

2d. Then write, as terms of the second member of the equation, the symbols or formulæ of the products resulting from the reaction.

3d. Adjust then, the factors of the symbols or formulæ so that the interchange will result in an equation.

Step 1, as given above, of course needs no comment.

The data for the second step must be made either a matter of memory, or else be determined by actual experiment. In a great many cases, remembering the conditions that affect an interchange, and which have been previously stated, there may be predicted by means of equations, what products *will be formed* in a chemical metathesis; but it should also be remembered, that a chemical equation differs in various ways from an algebraical equation; a chemical equation cannot be accepted as positively true, until verified by experiment; moreover equal amounts cannot be substracted from either side of a chemical equation and leave it true, etc.

The third step—the adjusting of the factors—is the important one, and in order the better to illustrate the principles involved, it will be well to work out a problem in this connection.

Assume the problem given to be, the construction of an equation showing the oxidation of iron sulphate by potassium permanganate.

Oxidation signifies an increase in the combining power (the quantivalence) of an element; reduction signifies a decrease in the combining power. Hence an oxidizing agent, in exerting its influence, loses in quantivalence: the substance oxidized, experiences a corresponding increase in its quantivalence.

The substances entering into the reaction to be considered, are: $K_2Mn_2O_8$, $FeSO_4$ and H_2SO_4. The products formed: $Fe_2(SO_4)_3$, K_2SO_4, $MnSO_4$ and H_2O.

Hence should be written—leaving space for the factors:

$K_2Mn_2O_8 + FeSO_4 + H_2SO_4 = Fe_2(SO_4)_3 + K_2SO_4 + MnSO_4 + H_2O$.

Next, regarding the change in quantivalence of the dominant element—the iron, in the iron sulphate—auxiliary equations are constructed, showing that the iron passes from the dyad to the tetrad state.

$$2\ FeO + O = Fe_2O_3$$

$$Mn_2O_7 = 2\ MnO + 5\ O$$

Two Fe require one O.

One $K_2Mn_2O_8$ yields five O.

Therefore 10 of a ferrous compound need 1 of the permanganate.

Hence adjust the quantity of the substance oxidized and the one performing this oxidation so that the gain in the quantivalence of the former be equivalent to the loss in quantivalence of the latter. Then arrange the factors for the other substances in accordance with the prescribed conditions of the solution (acid, alkaline or neutral), and balance the equation. Carrying out these suggestions there is obtained:

$K_2Mn_2O_8 + 10\ FeSO_4 + 8\ H_2SO_4 = 5\ Fe_2(SO_4)_3 + K_2SO_4 + 2\ MnSO_4 + 8\ H_2O$;

and testing to see whether this reaction is a true equation:

In first member:	In second member:
K— 2	2
Mn— 2	2
O—80	80
S—18	18
Fe—10	10
H—16	16

The factors all balance, and hence this equation is a correct one.

This way of working out equations of oxidation and reduction was arranged and systematized by Dr. Elwyn Waller, and is now taught at the School of Mines. Its chief advantage lies in the fact of insuring a thorough acquaintance with the *chemical* nature of the changes involved in reactions of this kind.

A very convenient method of constructing equations of oxidation and reduction, is given by Otis Coe Johnson, M.A.[1]

[1] Negative Bonds and Rules for Balancing Equations.—Chemical News, 1880, vol. xlii, p. 51. Also: a Study of Oxidation and Reduction. Appendix to Douglas & Prescott: Qualitative Chemical Analysis. Third Revised Edition, 1881.

This writer assigns to the term *bond* a meaning different from the sense in which the word is generally accepted. According to him, by the *bond* of an element is meant the amount of oxidation it is capable of sustaining, and hence his definition of a bond as "oxidizing force, and when an element has no oxidizing force or power it has no bonds." And further, "when its only capacity is that of a *reducing* agent, its bonds are represented by a negative number."

The rules given for ascertaining the bonds of an element, are the following:

1st. Hydrogen, in combination, has always one bond, and is always positive (H^{I}).

2d. Oxygen always has two bonds, and they are always negative (O^{-II}).

3d. Free elements have no bonds; thus metallic lead (Pb^{0}).

4th. The sum of the bonds of any compound is always equal to zero. Thus $H^{I}\,N^{+V}O_3^{-VI} = 0$

5th. Acid radicals are always negative.

Thus $H^{I}\,I^{V}O_3^{-VI} = 0$, or, $Pb_3^{VI}\,(PO_4)_2^{-VI} = 0$.

The bonds of the radical being equal to the number of atoms of hydrogen with which it is capable of combining.

6th. Metals in combination are usually positive. The most prominent exceptions are their compounds with hydrogen: $Sb^{-III}\,H_3^{+III}$.

Furthermore, as the oxidation of one substance must involve the reduction of some other, the number of bonds gained by the one is lost by the other.

From these principles a rule is derived for writing equations of oxidation if the products formed are known. The rule is: "The number of bonds changed in one molecule of each shows how many molecules of the other must be taken"—the words *each* and *other* referring respectively to oxidizing and reducing agent.

Applying this method to the problem before considered:

$$K_2Mn_2O_8 + FeSO_4 + H_2SO_4 = Fe_2(SO_4)_3 + MnSO_4 + K_2SO_4 + H_2O.$$

Mn_2 in first member has 14 bonds.

Mn_2 in second member has 4 bonds.

Loss = 10

Hence 10 $FeSO_4$

Fe in first member has 2 bonds.

Fe in second member has 3 bonds.

Gain = 1

Hence 1 $K_2Mn_2O_8$

The amount of H_2SO_4 needed, must be determined according to the prescribed condition of the solution.

In the "Lehrbuch der Pharmaceutischen Chemie" by Professor Schwanert, a rule for the constructing of chemical equations is given, which is based on algebraical principles.

In England Dr. James Bottomley[1] published a method also resting on algebraical principles.

To show its application our former problem is here solved once more:

$$a\,K_2Mn_2O_8 + b\,Fe\,SO_4 + c\,H_2SO_4 = x\,K_2SO_4 + y\,Mn\,SO_4 + z\,Fe_2(SO_4)_3 + w\,H^2O$$

(1.) $a = x$

(2.) $2a = y$

(3.) $8a + 4b + 4c = 4x + 4y + 12z + w$

(4.) $b = 2z$

(5.) $b + c = x + y + z$

(6.) $2c = 2w$

Substituting in (3.)

$$8a + 4b + 4c = 4a + 8a + 6b + c, \text{ or:}$$

(7.) $3c = 4a + 2b.$

And also:

(8.) $4c = 12a + 2b.$

Combining (7.) and (8.)

(7.) $3c = 4a + 2b$

(8.) $4c = 12a + 2b$

$c = 8a$

From (7.) $6c = 8a + 4b$

" (8.) $6c = 18a + 3b$

$0 = -10a + b$

[1] Chemical News, 1878, vol. xxxvii, p. 110.

Whence: $x = a$
$y = 2a$
$z = 5a$
$w = 8a$
$b = 10a$
$c = 8a$

Whence: $K_2Mn_2O_8 + 10\,FeSO_4 + 8\,H_2SO_4 = K_2SO_4 + 2MnSO_4 + 5\,Fe_2(SO_4) + 8H_2O$.

As is learned from this problem, the whole matter resolves itself into the solving of a set of simultaneous equations; either, then, of the three methods given will lead to the desired result; whether verdict may be pronounced in favor of any special one, to the exclusion of the others, is a question; each possesses merits of its own. However, it does not seem unreasonable to anticipate that yet another system may be devised, which, to a certain extent at least, will combine the valuable features of them all.

MINING LAW.

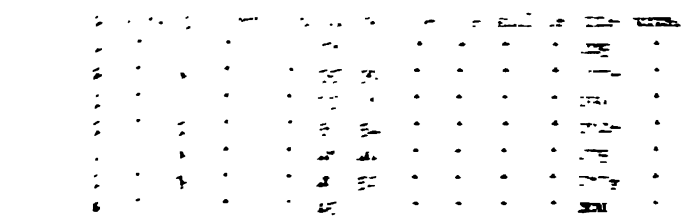
By EDWIN P. CLARK, E.M.

MINING, as we are often told, is one of the two fundamental industries of the world, and has been practiced from very ancient times. The Prehistoric races "probably carried on their mining operations by individual enterprise as freemen, without reference to particular ownership of the soil." The work was done in a very superficial manner without any care for the future, and hence the deposits were soon exhausted and abandoned. But, after awhile, when vast empires arose, and the princes of the land became more powerful, they laid claim to all the valuable mines, as the chief source of wealth, enforcing their claims with great harshness and tyranny. This was the case in ancient Egypt, where the kings owned all the mines, worked them by slaves, and appropriated to their own uses all the products. The mines were very systematically and thoroughly developed, but the unfortunate miners led a life of untold hardship and suffering. Egypt, as well as Asia Minor, where very rich gold placers existed, came under the dominion of the Persian kings, who acquired immense riches

from their mines. It was chiefly by means of this wealth that Darius and Xerxes were able to send such vast armaments against the Greeks. The Athenian Republic possessed several gold and silver mines, worked them by slave labor, and, before the period of the Persian War, divided the product among the citizens: subsequently the mines were leased, and the discovery of new deposits encouraged; the size of locations, methods of mining, etc., being regulated by law. Nearly all of the mining peoples of antiquity were conquered by the Romans. The mines, becoming the property of the State, were leased to contractors, who extracted all they could from them in the least possible time, and practically "gutted" them. The emperors finally abolished this system, on account of its bad results, substituting government supervision, and carrying on mining for their own benefit. Roman mining practically ceased after the fifth century, and mining operations were almost entirely suspended for several centuries.

The Germans began mining probably some time in the tenth century, in the Harz Mountains. "In the form of a local custom," says Dr. Raymond,[1] "the principle of mining freedom (Bergbaufreiheit) established itself, permitting all persons to search for useful minerals, and granting to the discoverer the rights of property within certain limits." This principle seems to be underlain by two ideas; first, that the miner himself is the party most entitled to the fruit of his labor; and, second, that the metals are applicable to the use of the general public, and hence their production should not be impeded by any exclusive or prohibitory regulations. At the end of the twelfth century the emperor and the territorial rulers claimed the mining royalty (Bergregal), as a foundation for laying taxes on the products of the mines. A conflict of the two ideas arose, which lasted some time, and finally resulted in the German mining law, as a sort of compromise. The principal provisions of the old German codes were briefly as follows: The discoverer of a valuable deposit "denounced" it, being compelled to work continually; after the ore body was clearly defined the making of a survey and application for a lease were peremptory; after the lease was issued delays were allowable for certain causes, such as bad air, or too much water, but if other parties offered to work the mine, operations must be

[1] For an account of the mining laws of different nations see Dr. Raymond's Report for 1869, pp. 179-223.



[illegible] 200 varas only are allowed [illegible] is limited by vertical planes [illegible]. The government always retains [illegible] and simply grants the right to mine, [illegible] with the law. In order to retain [illegible] necessary to keep at least four men at [illegible] for eight months of the year; if a mine stands [illegible] worked by less than four men for four consecutive [illegible] to relocation. The law prescribes certain [illegible] with regard to the proper working of the mines, [illegible] of pumps, ladders, etc.

In England the owner of freehold land owns everything [illegible] therein, to the centre of the earth, except gold and

[1] 1 vara = 4 palms = 48 fingers = 32¼ inches (approx.).

silver ores; "because gold and silver are the most excellent things which the soil contains, the law has appointed them as in reason it ought) to the person most excellent, and that is the king" (*Plowden*). There may be a distinction between an estate in minerals and the right to mine, which is shown, for instance in the immemorial custom of "tin bounding" which prevailed in Cornwall and Devon. "In substance it is this: the mine is parcel of the soil; the ownership is in the owner of the soil, but it is a parcel which, to discover and bring to the surface, may ordinarily require capital, skill, enterprise and combination; which, while in the bowels of the earth, is wholly useless to the owner as well as to the public; and the bringing of which into the market is eminently for the benefit of the public. If, therefore, the owner of the soil cannot, or will not, do this for himself, he shall not be allowed to lock it up from the public; and, therefore, in such case (unless, by enclosure, he may seem to have devoted the land to other important purposes inconsistent with mining operations, such as agriculture or building) any tinner, *i.e.*, any man employing himself in tin mining, may secure to himself the right to dig the mines under the lands, rendering a certain portion of the produce to the owner of the soil."[1] This extract sets forth the fundamental principle of the English Law of Mines.

The early mining operations in this country were mostly carried on upon private property, or land purchased from the Indians. In some cases special grants were made, such as that passed by the General Court of Connecticut in 1651, which licensed Gov. John Winthrop to mine lead, copper, tin, antimony, etc., etc., "to enjoy forever said mines, with lands, woods, timber and water within two or three miles." After the separation from the mother country the "crown right" vested in the Federal Government; this was recognized in the Act of May 20th, 1785, authorizing the sale of the public lands, in which one-third of all gold, silver, lead and copper mines were reserved to the government; however, this reservation has never been enforced, and is, to all intents and purposes, a dead letter. According to the system pursued in the disposal of the public territory by the General Land Office, which was established in 1812, the lands are first surveyed,[2] and then offered for sale at

[1] Lord Denman's opinion.—Rogers vs. Brenton; 10 Q. B. 26.

[2] The country is divided into Townships, 6 miles square, by "Township lines," running due E. and W., and "Range lines," running due N. and S. Both are

$1.25 per acre, but in all cases, lands valuable for mineral deposits and salt springs have been reserved. As early as 1807 provision was made for leasing the lead mines of Illinois to miners, who were to return 6 per cent. of the product to the United States; the first lease was granted in 1822. An attempt was also made to lease the copper lands of Lake Superior, but in neither case did the plan work well. Finally, in 1846 the lead lands of Illinois, Arkansas, Missouri and Iowa were offered at $2.50 per acre, and in 1847 the Lake Superior copper lands at $5.

In the absence of any established legal methods during the early days of mining in California, the miners of each "mining district" were the supreme fountains of the law. They assembled in mass meeting and passed "mining codes," which prescribed the boundaries of the district, the size of claims, the proper method of recording them, and the amount of "assessment work" requisite to retain the "possessory title." This last provision was necessary in order to prevent parties from taking up claims for speculation simply, without any intention of engaging in legitimate mining. Nearly all of these codes allowed the discoverer of a vein to take up two claims, but restricted each subsequent locator to one. This custom spread from California through all the western territories, in many cases the county or territorial assemblies enacting mining codes. The following tabulated statement will show the main features of a few of these codes, which varied very much in different places.

Immense quantities of mining land were located and held under these regulations, and the titles obtained under them are still valid, for the United States Mining Laws of 1866 and 1872 confirm the various "local laws and customs" when not inconsistent with the national law.

Until the year 1866 the miners of the West had no legal right to their mines, strictly speaking, but were trespassers upon the public domain; for the title to the land still rested with the United States, as no provision had been made for the disposal of the mineral lands, they having always been re-

numbered in regular order from 1 upward (Townships from Base lines, Ranges from principal meridians), and Townships are known by a combination of Township and Range numbers. A complete Township contains 36 sections, 1 mile square. Each section is subdivided into quarters, and these again into quarters. This system has been applied to all of the States and Territories except the Original Thirteen Colonies, Ohio, Kentucky and Tennessee.

Locality.	Size of Claims.			Assessment Work.			Date of Approval.
	Lodes.		Placers.	Amount.	Equivalent Labor.	Time Holding.	
	Length.	Width.					
Sierra Co., Cal.	200 ft.	500 ft.		$100		12 months.	
Nevada Co., Cal.	100 ft.*			100	20 days.	1 year.	Dec. 20th, 1852.
North San Juan District			180 ft. by 80 ft.	500		2 years.	Nov. 5th, 1854.
Nevada Co., Cal.							
Sacramento Co.	200 ft.*			60	20 days.	1 year.	Jan. 22d, 1857.
Pilot Hill Dist.	(Tunnel and shaft.)		100 ft. by w'th of hill.	25		1 week.	
Calaveras Co		(Gulch.)	150 " " 50 ft.	Must begin work within three days after obtaining water.			
		(Surface.)	200 " " 100 ft.				
Copperopolis Dist.	150 ft.	300 ft.			1 day.	1 month.	Aug. 3d, 1860.
Calaveras Co.					May 1, to Dec. 1.		
Tuolumne Co.	150 ft.*	300 ft.			1 day.	30 days.	Sept. 1st, 1858.
				or $100		6 months.	
Columbia Dist.	(Flats and Hills.)		100 feet square	Must begin work within five days after obtaining water.			
Tuolumne Co		(Ravines.)	100 feet				
New Kanaka Camp.		(Creek.)	200 ft. bank to bank.		1 day in 3.		
Tuolumne Co., Cal.		(Gulch.)	200 " by 50 ft.	When water available.			
	(Bars and Flats.)		2 " " 50 "				
State of Nevada	200 ft.*	200 ft.*	(Must excavate	50 cubic feet earth or 5 cubic feet rock.†		1 year.	Feb. 27th, 1866.
Virginia Dist.	200 " *			$10	3 days.	1 month.	Sept. 14th, 1859.
Storey Co., Nev.				or $40		6 months.	
	(Surface and Hill.)		100 feet square	Must begin work within ten days after obtaining water.			
	(Ravine and Gulch.)		100 " bank to bank				
Reese River Dist., Nev.	200 ft.*	200 ft.					June 4th, 1864.
State of Oregon	300 " *	150 "		$50		1 year.	1857 (?)
Territory of Idaho	200 " *	100 "		100		forever.	Feb. 4th, 1864.
Territory of Arizona	600 "	600 "	Must sink 30 feet or tunnel 50 feet.			"	Jan. 1st, 1865.

* Including all "dips, angles, variations," etc. † Commuted by payment of 2 cents per foot. Work to the amount of 50 cents per foot holds for 2 years.

served from sale: furthermore, it was necessary that the land should be surveyed before it could be pre-empted, and this had not been done. In that year it was proposed to sell the mines to the highest bidder: this would obviously have been a great injustice to the actual possessors; after a hard struggle the bill authorizing this plan was defeated in Congress. It had, however, become apparent that the situation called for some legislative action; consequently the Act of July 26th, 1866, was passed. This opened the mineral lands of the country to exploration and occupation, subject to the local laws and customs that prevailed in the various districts. It made provision for obtaining the United States patent to lode claims after $1,000 had been expended upon them, if they were properly located and held under the district rules, but limited such patent to one vein only, no matter how many might exist within the boundaries of the claim. The patent conferred the right to follow the vein, together with its "dips, angles and variations," to any depth, although it might pass under the adjoining land. The act also made the following provisions: 1st. That the local legislatures might provide rules for working mines, involving easements, drainage, etc.: 2d. That in case of contest of title all patent proceedings should be stayed until the question was decided in the courts: 3d. Granting the right of way for ditches, canals, etc., for mining or other purposes: 4th. Allowing agricultural entries on supposed mineral lands, when no mines had been discovered on them: 5th. Permitting the Secretary of the Interior to decide, after survey, what lands should be considered agricultural and what mineral. This act was received at first with great gratitude and rejoicing by the miners, but before very long it became evident that in practice it would not work very well. The principal objections to it, as pointed out by the Hon. E. F. Dunne,[1] of Nevada, were as follows: 1st. The size of claims, depending on local laws, varied greatly in different places: 2d. Restricting the patent to one vein: 3d. Not determining, when two veins crossed, to whom the ore in the intersection belonged: 5th. Not determining, when two veins united, to whom the ore below belonged: 5th. Not providing for a uniform tenure of possessory claims: 6th. Not providing how to determine whether a deposit is a vein or not: 7th. Not extending the law to placers: 8th. Not preventing the "floating" of locations. The law was amended in 1871, but

[1] Raymond's Report for 1870, pp. 421–444.

was superseded by the Act of May 10th, 1872, which is still in operation, the leading features of which will now be described.

All the mineral lands of the country, both surveyed and unsurveyed, are now open to exploration and occupation. Surveyed lands are classified as mineral, agricultural, timber, etc., by the Deputy-Surveyor in the field at the time of survey, and are offered for sale accordingly. This classification is subject to correction, by proof, in the district land offices. All land is considered mineral that is more valuable for mining than farming purposes. If agricultural locations have been made on land designated as mineral, or *vice versa*, and there is any controversy, the character of the land must be fully established before a competent officer. In applying for a patent to agricultural land, it is necessary to present an affidavit affirming the non-mineral character of the land; if deposits of valuable minerals should be discovered after the issuance of the patent they belong to the owner of the land; but in no case does an agricultural patent convey ownership in mining lands already known to exist, or which may be discovered before the patent is issued. "It is thought that *bona fide* settlers upon lands really agricultural will be able to show by a clear, logical and succinct chain of evidence that their claims are founded upon law and justice; while parties who have made little or no permanent agricultural improvements, and who only seek title for speculative purposes, on account of the mineral deposits known to themselves to be contained in the land, will be defeated in their intentions."[1] If mineral entries are made on agricultural land the claimants must show that valuable mines have been actually discovered. Unsurveyed lands are considered mineral when they are so reported by "common fame," and occupied as such. The mining lands of Michigan, Wisconsin, Minnesota, Missouri and Kansas are excluded from the operation of the mining laws, and can be purchased in the same quantities and at the same price as agricultural lands.

Any person who is, or has declared his intention of becoming, a citizen of the United States, can locate mining claims, and obtain patents for them. There are three classes of claims contemplated by the mining laws—lodes, placers, and mill-sites. I. Lodes are "mining claims upon veins of quartz or other rock in place, bearing gold, silver, cinnabar, lead, tin, copper, or other valuable deposits." If located prior to May

[1] Land Office Instructions, Sec. 99.

10th, 1872, they must be governed as regards size by the local laws in force at the time of location. After that date they "may equal, but shall not exceed 1,500 feet in length along the vein. No claim shall extend more than 300 feet on each side of the middle of the vein at the surface, nor shall any claim be limited by any mining regulation to less than 25 feet on each side of the middle. The end lines of each claim shall be parallel to each other." In Colorado and Dakota the locator is restricted to 150 feet on each side of the middle of the vein: in Boulder, Gilpin, Clear Creek, Park and Summit Counties, Colorado, he is still further restricted to 75 feet. II. Placer claims may be located upon any form of deposit except veins or other rock in place. They cannot exceed 20 acres for one individual locator: an association of persons, not exceeding eight in number, may pre-empt 20 acres apiece, and make one location when the claims are contiguous. If the placer is on surveyed lands, it must conform in its exterior boundaries with the legal subdivisions, in which case no survey or plat is required when applying for a patent, but simply a description of the land; *e. g.*, "S.W. ¼ of the N.W. ¼ of Section 28, Township 17 N., Range 64 E." On unsurveyed lands the claim may be of any shape, and a survey and plat are requisite. III. Non-mineral land, to the extent of five acres (not contiguous to a lode or vein), occupied for mining or milling purposes, or as the site of a reduction works, may be located and patented as a "mill-site," either in connection with a lode or not.

The manner of obtaining the government title to mining property at the present time will now be explained. The prospector is generally the first party interested. He sets out properly equipped, and when he is satisfied that he has "struck a lead" he locates a claim. This is done in the following manner: A "discovery" shaft is sunk, or tunnel driven, at least ten feet, to determine whether the claim carries mineral, and also to determine, as far as possible, the direction of the vein, lode or crevice; a notice is posted on a stake at the point of discovery designating the name of the lode, the name or names of the locators, the number of feet claimed, and the date of discovery; the claim is laid out on the surface with a stake at each corner and one in the middle of each side line; these stakes are numbered in regular order, beginning with No. 1 nearest to the nearest quarter sec-

[1] United States Law, Sec. 388. (Revised Statutes, Sec. 2320.)

tion corner; each one should be marked with its number, the name of the lode, and the date of location; *e. g.*, "N. W. Cor. No. 3, Columbia Lode, Located Jan. 1st, 1884." Within twenty days[1] after discovery the claim must be recorded and a copy of the location certificate filed with the proper recorder of the district, who is generally the county clerk. This document should contain the following facts:— 1. The name of the Lode. 2. The name or names of the locators and the proportional share of each. 3. The dates of location and discovery of mineral. 4. The number of feet along the vein claimed on each side of the discovery shaft. 5. The number of feet in width claimed on each side of the centre of the vein (which is supposed to be indicated by the point of discovery). 6. A general description of the lode by courses and distances, with "the course and distance as nearly as practicable from the discovery shaft to some permanent, well-known points or objects, such, for instance, as stone monuments, blazed trees, the confluence of streams, points of intersection of well-known gulches, ravines or roads, prominent buttes, hills, etc., which may be in the immediate vicinity, and which will serve to perpetuate and fix the *locus* of the claim;"[2] also "the names of adjoining claims, or, if none adjoin, the relative positions of the nearest claims."[3] The law does not require that this information shall be gained by means of an accurate survey, but that is the best way to procure it; otherwise it might become necessary to record and file an amended location certificate when applying for a patent. And in fact the greatest care should be exercised in complying in every particular with the United States law and the local laws not in conflict therewith, for the foundation of absolute title rests upon priority and accuracy of location.

If the prospector is the first person in the locality, he will of course take up the full amount of ground allowed him by law, and will probably locate several claims, covering the vein as nearly as he can. Afterward it may be discovered that he has not located his claim exactly along the line of the vein; then he or somebody else will lay out another claim, benefiting by the knowledge gained as to the direction of the lode: this later claim may overlap a portion of the first one, but the prior

[1] Fifteen days in Idaho; three months in Colorado and New Mexico.

[2] Land Office Instructions, Sec. 14.

[3] Ib., Sec. 15.

locator owns the ground in conflict if he has complied with the requirements of the law. This process may go on almost indefinitely, until eventually the whole surrounding country is plastered over with claims; the first hundred or so are of the simple rectangular shape, but the later ones are often of very grotesque shapes, caused by the desire to take up little spaces which may be left vacant by the preceding locators, either intentionally or accidentally. As a matter of fact locations are often made without any show of paying mineral.

From the time of location until a patent is obtained the ownership of the claim is in a sort of probationary state. In order to legally retain the "possessory title" it is necessary to expend $100 in labor or improvements upon the claim within one year after location, and during each calendar year thereafter until the patent entry is made. An affidavit must be recorded and filed stating that such expenditure has been made, and such record is *prima facie* evidence of the fact. Failure to do this is equivalent to an abandonment of the claim, and it can be relocated or "jumped" by any other parties in the same manner as an entirely new claim, unless the owners resume work before such relocation. In many mining camps the first of January is a day of great activity, and sometimes of bloodshed, for in many cases, from litigation or other causes, the owners of valuable claims fail to do the "assessment work," and then it becomes a question of might who shall obtain possession of the property. An abandonment of a claim or any portion of it may be legally made by filing the proper certificate; in which case the party may remove his machinery and all ore extracted. When, at the end of the year, one of several co-owners fails to contribute his proper share of the expenses of the "assessment work," 180 days after notice has been served upon him, either in writing or by continuous publication in a newspaper for 90 days, if he still fails to contribute, his interest passes to the other partners; but when a co-owner fails to contribute his share of the *actual* expenses over and above those *required* by law to hold the claim, his partners can only recover by means of a civil suit in the regular courts. The proprietor of an unpatented mine must constantly be on the lookout, to see that nobody locates over him or extracts ore from his ground. If he finds that an application for a patent has been made, including any portion of his location, he must enter an adverse claim, the proceedings under which will

be explained presently; otherwise, if a patent finally issues covering any part of his property, without his entering a protest, he loses all right and title to the ground in conflict. He can begin a suit in equity before the regular courts, but he has very little chance of success unless he can prove that fraud was practised in obtaining the patent.

Prospecting or assessment work can be done by means of a tunnel, which may be entirely outside of the claim; work done in one tunnel may be counted as done on several contiguous claims if of sufficient amount. The proprietors of such a tunnel may locate and patent all blind lodes or veins encountered within 3,000 feet of the "face" on the line of the tunnel not previously known to exist, the "face" being defined as the point at which the tunnel actually enters cover; they are also entitled to the timber growing on the surface directly overhead. To avail themselves of the benefit of a "tunnel right," the owners must post a notice at the entrance giving their names, the direction, height and width of the tunnel, and the course and distance from the face to some permanent well-known objects in the vicinity; also mark the actual or intended course on the surface by stakes at proper intervals. A location certificate must be recorded and filed, having been made out in a similar manner to certificates for lodes. Failure to work for six months amounts to an abandonment. These claims cannot be patented, as they are only for the purpose of exploration.

For all practical purposes locators or their assigns absolutely own their claims as long as they fulfil the requirements of the general and local laws, as there is no obligation to obtain a government patent. The proprietors of a regularly located claim have the exclusive right to all the surface ground included within their boundary lines, with the timber growing thereon. On lodes they have the right to all veins throughout their entire depth, the tops or apices of which are inside the surface lines; but this right is confined to such portions of the veins as lie between vertical planes drawn downward through the end lines of the location (which must be parallel). This gives the right to go under the surface of adjoining claims, and has probably, directly and indirectly, given rise to more litigation in mining than any other one thing. Where there is a clearly defined fissure vein no difficulty arises; but where there is any doubt at all about the "apex," "outcrop," "walls," "pitch

of the vein," or any other of a thousand and one contingencies, trouble is sure to follow. As a matter of fact, in many mining districts, notoriously at Leadville, the law is not strictly adhered to, and owners of claims are confined to the ground included within vertical planes drawn through their boundaries. Where two or more veins cross, the prior location has the right to the surface, ore, etc., within the intersection. A placer location conveys the right to deposits, other than those in "rock in place," included within vertical planes drawn through the boundary lines; the locator has no right to any lodes known to exist at the time of location, or that may be discovered before he gets a patent, but any that may be discovered afterward belong to him.

The final steps in the process are the patent proceedings. Any claim on which $500 has been expended, and which has been properly located and held according to the national and local laws, can be patented. A letter is addressed to the Surveyor-General of the State or Territory (accompanied by $25 as a deposit for work in his office, and a copy of the location certificate), requesting an order for survey, and designating the Deputy-Surveyor whom it is desired to have make it. If the Surveyor-General finds the location certificate correct, he sends the order for survey to the Deputy-Surveyor, denoting what the official number of the survey will be. The claim is then surveyed,[1] and four plats and two sets of field-notes made, which are sent to the Surveyor-General for his approval. The survey must agree with the location survey. On the plats the ground which it is desired to patent is colored, excluding any part of a conflicting claim which may have been offically surveyed previously. If the Surveyor-General finds that the survey agrees with the location certificate and the plats of surveyed claims in the vicinity, he indorses the plats and field-notes "approved," at the same time certifying that $500 has been expended in labor or improvements, he having been advised of that fact by the Deputy-Surveyor. One plat is sent to the Register of the proper land-office to be placed on file there; one plat and set of field-notes are kept by the Surveyor-General; two plats and the other set of field-notes are sent to the Surveyor, who turns them over to the applicant after his bill

[1] For a description of the method of making surveys, see an article in this magazine for March, 1881, entitled "Surveying of Mining Claims in Colorado," by Richard A. Parker, C.E.

has been paid. One plat, together with a notice of intention to apply for a patent, and a full description of the claim, which is essentially a copy of the location certificate, are posted on the claim in some conspicuous place in the presence of two witnesses who must make affidavit of the fact. An application for a patent is now filed with the proper Register and Receiver, setting forth the fact that the applicants hold the "possessory right" to the claim in conformity with the law; also a properly certified copy of the location certificate; an abstract of title; the affidavit of the witnesses to the posting; and the set of field-notes and plat remaining, which are to be posted conspicuously in the land-office for sixty days. A notice is now published for sixty days in the newspaper issued nearest the claim, stating that a patent has been applied for, and giving a description of the premises. This notice, a copy of which must also be posted conspicuously in the local land-office, should embrace all the *data* given in the location certificate. After the sixty days have elapsed, the applicant will file affidavits stating that the notice was published for the required time, and that the notice and plat remained posted on the claim during the period of publication. If no adverse claim has been entered the ground is paid for; $5 per acre or fractional part for lodes and mill-sites, or $2.50 for placers: the Receiver issues a receipt for the money, and the papers are transmitted to Washington to be examined at the General Land-Office, and if found correct the patent is issued. If an adverse claim has been made, the ground cannot be paid for until the applicant's title has been confirmed, after a suit in the courts, and the judgment roll filed in the land-office. The date of "entry" or payment is considered as the date of patenting, and all rights conferred by patent are held from that time. A full set of papers in each case would embrace the following:

1. Application for patent, accompanied by a copy of the location certificate, and an abstract of title.

2. Official plat and field-notes approved by the Surveyor-General, with his affidavit of $500 expenditure.

3. Proof of posting notice and plat on the claim.

4. Proof that plat and notice remained posted on the claim during the period of publication.

5. Register's certificate of posting notice and plat in his office for sixty days.

6. Proof of publication, with copy of notice.

7. Statement of fees and charges paid.

8. Affidavit of citizenship of owners.

9. Power of Attorney of agent (if the owners are not the applicants).

10. Copy of Articles of Incorporation (if the application is made by a company).

11. Proof that no known vein exists in the claim (in the case of a placer).

The cost of a patent is approximately $190 for a lode 1,500 feet by 300: $25 to the Surveyor-General, $50 to the Deputy-Surveyor, $15 for certified copies and abstracts, $10 for filing, $20 for publishing, $15 for notary's fees, and $55 for land (10.33 acres). After a United States patent has been issued for a claim, or, in fact, after entry has been made, the owner can hold it against all comers and claimants, whether he works it steadily or allows it to remain idle forever.

In case there is any adverse claim it must be entered within the period of publication, or the adverse claimant will have no means of redress through the Land-Office. Only interested parties can make adverse claims. "Any state of facts which shows that the person alleging the same has a better right to the premises sought to be patented, or any portion thereof, than the applicant, is the proper subject-matter of an adverse claim."[1] A survey of the conflicting claim must be made by a U. S. Deputy-Surveyor, and a plat made showing the "nature, boundaries, and extent" of the adverse claim. The protest must be made upon oath, and must be accompanied by a copy of the location certificate of the conflicting claim and an abstract of title. "The adverse claimant must, within thirty days after filing his claim, commence suit in a court of competent jurisdiction, to determine the question of the right of possession, and prosecute the same with reasonable diligence to final judgment; and a failure so to do shall be a waiver of his adverse claim. All proceedings, except the publication of notice and making and filing of the affidavit thereof, shall be stayed until the controversy shall have been settled."[2] After the rendering of judgment the party entitled to the ground in dispute may receive a patent for it after going through the proper proceedings.

According to the decisions of the courts and the Land-Of-

[1] American Mining Code, H. N. Copp, p. 37.

[2] U. S. Law, Sec. 394 (R. S. Sec. 2326).

fice the following may be patented under the mining laws: Deposits of clay, diamonds, fire-clay, kaoline, limestone, marble, mica, petroleum, plumbago, salt, slate, sulphur, and umber; if found in veins or "rock in place" as lodes, otherwise as placers. Cinnabar and copper must be patented as lodes, auriferous cement, and borax as placers. Iron ore deposits are patented as lodes or placers, according as they are found in veins or "rock in place," or not. Coal lands may be purchased at the rate of $10 per acre when more than fifteen miles from any railroad, and $20 when within that distance; 160 acres can be taken up by one individual or 320 by an association.

All mining claims are subject to the right of way, for mining or other purposes, of any ditch or flume, tramway or pack-trail in use, or that may be laid out across the location; but this right of way cannot be exercised against any location made prior to the claim of the right of way, without the consent of the claim owners, except by condemnation, as in case of land taken for public highways; and this ditch or flume must be so constructed as not to injure vested rights. The right to use running water for mining purposes can be acquired by appropriation if not used by anybody else. Water rights vest by priority. The miners are responsible for damage caused by tailings and floods from ditches. In California the damage done by the tailings of the hydraulic mines has been so great that the farmers have taken out injunctions against the miners in many cases.

In the absence of legislation by Congress the legislatures of the States and Territories are permitted to make rules governing the working of mines. Nearly all of the mining States and Territories have made provisions for miners' liens, and Colorado has quite an elaborate code providing for drainage of mines, selling of ores, water rights, penalties for stealing ore, etc., etc.

The provisions of the United States Mining Law relate entirely to the question of title, there being no attempt to exercise a complete government supervision of the mining industry, such as is carried on in Germany. The foundation of our law is the old German idea of mining freedom, on which we have engrafted the English idea of absolute ownership in the soil and all it contains (*including* gold and silver), enlarged by the right to follow veins to any depth under neighboring property, and limited by giving the same right to others. After the

government has deeded away the mining lands it has no more control over them. It has been objected that this policy does not tend to the greatest development of the mines; but it was the experience of the western miners that capitalists could not be induced to invest in their mines until the title was absolutely unclouded. It may also be questioned if the condition that the tenure shall depend upon the doing of "assessment work," as in Mexico, does not conduce to a rapid exhaustion and abandonment of the property, while, where the proprietor knows that he cannot be disturbed in his possession, he will conduct his operations so as to derive the greatest yield from the mine for all time, even though it should become necessary to keep it idle for a few years.

ERRATA IN VOL. V., NO. 2.

Page 98, line 5 from bottom, for *another* read *other*.
" 99, last line but one, for *passed* read *pressed*.
" 104, line 8 from top, for 366.2596 read 366.2591.
" 104, line 23 from top, for *orbit* read *cubit*.
" 104, line 28 from top, for *on* read *in*.
" 105, for *plain* read *plane*.
" 105, for *evacuation* read *excavation*.
" 106, line 17 from bottom, insert *the* before *doctrine*.
" 107, line 22 from top, for *walls* read *wall*.
" 110, line 5 from bottom, for *O*riented read *oriented*.
" 113, line 11 from bottom, for 3.14119 read 3.14159.
" 118, lines 14 and 16 from bottom, for *would* read *could*.
" 122, line 28 from top, for *derived* read *desired*.
" 123, lines 20 and 29 from top, for 25,025 read 25.025.
" 126, line 19 from top, for *seven hundred* read *a thousand*.

PROFESSIONAL NOTES.

Sanitary Engineering.

Rival Systems of Heating.—In the *North American Review* for February, 1884, are two articles, one by Professor W. P. Trowbridge, and the other by Dr. A. N. Bell, which appear under the one heading, "Rival Systems of Heating." Each gentleman has evidently been requested to state his views as to the respective merits of the different methods of warming buildings, and the following synopsis and comparison of their papers may be of interest.

Only the more common methods of heating are treated of—the open fire, the stove, the furnace, and steam heating; and a reading of the two articles shows clearly that the writers approached the subject from somewhat different directions: Professor Trowbridge, mainly from the standpoint of the sanitary engineer, engaged with the problem of warming and ventilating large buildings: Dr. Bell, from the position of the householder, whose ambition should be to provide a comfortable and healthy house for his family. Bearing this in mind, it is easy to see how the opinions expressed are in the main in harmony, although exception may perhaps be taken to some of the conclusions.

Professor Trowbridge starts with the general principle that "the warming and ventilation of dwelling-places are equally indispensable to health, and that they are, to a great extent, inseparable in their relation to each other."

A comparison of the four methods of heating mentioned "involves, for each, the cost of the apparatus and its durability, the cost of fuel and attendance, and the efficiency of the apparatus for heating and ventilation." Professor Trowbridge explains that because the open fire only heats by radiation it is very inefficient, and, "while its first cost may not be great, the cost of fuel, except when such open fires are mere adjuncts to some other system, renders their mode of heating, as houses are now constructed and occupied, quite out of the question for the ordinary householder." The open fire-place is, however, a most efficient ventilator.

Regarding the close stove, which he states is by far the most prevalent method of heating, the reasons for its popularity are easily recognized. The stove is easily and cheaply placed in any room of a building where there is a flue to run a pipe into. The fire is easily regulated; "and as it is generally employed with the minimum of ventilation, and often with almost none at all, the economy of heat is all that can be desired."

But in proportion as good ventilation is demanded this efficiency of heating disappears. Again, when buildings with many rooms are to be heated by stoves, "the economy which might be practicable for a single room then disappears to a great extent, owing to the increased cost of attendance, as well as waste."

Professor Trowbridge thus comes to the conclusion that neither the

open fire nor the close stove satisfies all the demands of health, comfort and economy, and writes that "two modes of heating are in vogue by which the demands of economy and comfort are met, viz.: the hot-air furnace and the steam-heating apparatus." Under the term "comfort" he undoubtedly includes health, for it can no more be separated from comfort, in practice, than can ventilation be separated from heating. But before going any farther, let us turn back and look at Dr. Bell's opinions on those more elementary methods of heating—the fire-place and the stove.

Dr. Bell states that the economy of heat is a primary element in the art of preserving health. Of the various means to this end, fire is the subject of his article, "and with special reference to the relative merits, from the sanitary point of view, of stoves and furnaces as compared with steam." "Simply to obtain the necessary temperature would be an easy matter, but ventilation must be constantly kept in view, and this cannot be secured without some sacrifice of heat." He disposes of the fire-place by quoting Count Rumford as saying, "while the draughts chill one part of the body, the rest is roasted by the fire in the fire-place, and this cannot but be injurious to health." However, Dr. Bell does not rob the lover of the fireside glow without giving him a substitute, as he shows farther on.

He considers the close stove to excel all other modes of heating, in an economical point of view. A fire-place gives to the room only about 12 per cent. of its heat; the close stove gives out 85 to 90 per cent. of the heat of the fuel burned. But here lies the great difference: while through the fire-place great volumes of air pass from the room, a close stove with a brisk fire will, on the average, be the outlet for only about a tenth of the capacity of the room warmed.

Of course, any exact figures are impossible for a general statement like this made by Dr. Bell, but it serves to show the great inferiority of the close stove as a ventilating apparatus in itself.

The chief advantage of close stove heating is, "that warming the air by means of a close stove is more quickly accomplished and more easily kept up than by any other means."

"The essentials for healthy stove-heating are a brick-lined fire-chamber, exhaust flue for foul air, means for supplying moisture, and provision for fresh air supply." A foul-air shaft may be made by fitting a larger pipe around the stovepipe, exhausting into the chimney. (Dr. Bell ignores here the possibility of down draughts in the smoke flue.) A fresh-air inlet can be made between the two sashes of a window, by fitting a strip of board under the lower sash. Open fire stoves combine, in great measure, the advantages of the open fire and the close stove; providing more ventilation than the latter, and giving more heat to the room than the former.

There is a curious instance of the mistakes that a person, excellent in his profession, may make when he passes beyond the boundaries of his strictly professional course of study, in the statement by Dr. Bell that exhaust flues should never be placed in outer walls, for the reason, that "the greater density of the outer cold air prevents the ready ascent of the warmed and rarefied air from within." He falls into the very common error of supposing that the movement in an aspirating chimney is due, not to the greater weight of the colder and denser air outside forcing the rarefied air up the chimney, but to the rarefied air rushing its way out by some force inherent in itself.

Reviewing now the opinions of the two writers, on the fire-place and stove, the fire-place is seen to be an excellent ventilator but a very poor heater, and therefore not economical in outlay of money, although healthful if draughts are prevented. The stove in itself is practically no ventilator at all, but is a very efficient heater, and therefore economical in an immediately pecuniary sense, although not economical of health. In proportion as its healthfulness is increased by supplying fresh and foul air inlets to the room, its economy of heat is lessened. The open stove is essentially a stove with these means of ventilation supplied. While the fire-place, or stove modified to meet the demands of health, may be economical according to the definition of the word given by Professor Trowbridge, when a single room or a small house is to be warmed, either method becomes extravagant in its application to large buildings. The proper use of the fire-place was mentioned in the statement, that it should be used only as a cheerful and healthful adjunct to some other method of warming.

Taking up once more the two papers where we left them, there yet remain to be considered the other two methods of heating—furnace, and steam—and their respective advantages and disadvantages. The furnace and the steam apparatus are much broader in their scope than the stove or fire-place, and can be applied to the warming of extensive buildings, as well as smaller houses. The question is, which method is the more economical, in the right sense of the word?

Both gentlemen define the furnace as an encased stove outside of the apartments to be heated, generally in the cellar of the building. It is provided with a fresh-air inlet, through which the air enters, passing over the heating surfaces, and then through flues to the different rooms above. The heated air of the rooms passes by spontaneous action through outlet flues, or into the halls, and so to the upper stories.

Dr. Bell gives as an essential of satisfactory warming by furnace-heat, a good chimney draught; and this should be stronger than that of the hot-air pipes into the rooms; "for, if the chimney draught exceeds that of the hot-air pipes, all the gaseous emanations from the inside of the furnace—and if it has crevices or is of cast-iron and overheated, all around it on the outside—will be drawn into the chimney." The area of the inlet should be one-sixth of a square foot for every pound of coal burned hourly in cold weather; and the collective area of the hot-air pipes should not be more than one-sixth greater than the area of the cold-air inlet. This Dr. Bell states will give a temperature of 120° F. when at zero outside.

Professor Trowbridge states: In the furnace as usually constructed the air is heated to 250° to 400° F., and then mixed with cool air and brought down to 150° or 200°. In the rooms it is supposed to be still further mingled with cool air leaking through windows and doors.

Steam heating is described by Professor Trowbridge as imparting the heat of combustion to water, which acts as a medium to carry the heat through small pipes to the points where it is utilized.

There are two methods of utilizing this heat. In one, called direct radiation, the steam is carried to radiators placed in the rooms. This, like the close-stove system, gives no ventilation unless some other means is taken to provide it. A radiator differs from a close stove, however, in that it is practically never raised to a temperature higher than 310° F., or lower than 215° or 220°, while the surface of a close stove

may, under some circumstances approach 950°. Ventilation is easily attained with direct radiation.

The other method of utilizing the heat of steam is called indirect radiation, and consists in placing heating coils in the basement, directly beneath the room to be warmed, and letting air pass over these on its way to the room. This corresponds with furnace heating, as direct radiation does with the close stove.

"Low temperature currents only are generated; and as the proper action of the apparatus can only be kept up by a continuity of flow in and out of the space to be heated, the two effects of heating and ventilation are most effectively combined."

Perhaps the best way to compare the views given on the merits of these two systems of heating will be to arrange the *pro* and *con* arguments in opposing ranks, for the purpose of review, from which can be gathered a more definite idea of their relative strength and number; recalling Professor Trowbridge's principle, "that a comparison of the various methods must include the cost of the apparatus, the cost of attendance, the cost of fuel, and the incidental advantages and disadvantages belonging to each."

ADVANTAGES OF FURNACE HEATING.

Dr. Bell.—It is more economical than steam, more uniform, more easy of management, more suitable for small areas to be warmed, and is free from the noises and dangers of steam.

Professor Trowbridge.—The first cost is less.

DISADVANTAGES OF FURNACE HEATING.

Dr. Bell.—None mentioned.

Professor Trowbridge.—Beyond a certain limited distance from the furnace the difficulty of conveying heated currents increases very rapidly; hence, for large buildings, several furnaces must be provided, and the economy is proportionally diminished. Where there are branch ducts leading to different rooms, one branch may overpower another, causing excessive heat in one room and a deficiency in another. Proper ventilation is difficult, and the highly heated currents are apt to be dry and unhealthy. There is more or less dust connected with it. There is danger from fire. "The hot-air furnace system is of all the most difficult to manage, so far as uniformity and control of temperature is concerned." As he shows later, this is because there is only a single furnace for several rooms.

ADVANTAGES OF STEAM HEATING.

Dr. Bell.—None mentioned.

Professor Trowbridge.—"Almost absolute freedom from risk of fire when the boiler is outside of the walls of the building to be heated, and comparative immunity under all circumstances." With the indirect system "a most thorough ventilation may be secured, and is, in fact, concomitant with the heating." "Whatever may be the distance of the rooms from the source of heat, a single steam pipe of small diameter conveys the heat."

With indirect radiation, a vertical flue from a radiator to each room places the flow under the absolute control of the occupants. "Uniformity of temperature, with certainty of control, may thus be secured."

The air currents have a low temperature. No injurious gases can pass from the furnace into the air flues. "One of the conspicuous advantages of steam heating is that the most extensive buildings, whole blocks, and even large districts of a city, may be heated from one source, the steam at the same time furnishing power, where needed, for ventilation or other purposes, and being immediately available also for extinguishing fires, either directly or through force pumps." No other system can be so readily adapted to procuring good ventilation as steam heating.

DISADVANTAGES OF STEAM HEATING.

Dr. Bell.—It is less economical than furnace heating, less uniform, less easy of management, and less suitable for warming small areas. It is noisy. "Irregularities of the fire in steam heating are a constant source of inconvenience, and sometimes of danger." When the fire dies a partial vacuum is formed, and when steam is made again it comes in contact with the condensed water, and violently drives it back and forth so as sometimes to cause cracks and leaks, besides producing noises. "Hence, direct steam heat, which for warming alone is altogether superior to indirect, has been well-nigh abandoned." This seems a rather surprising statement to be made by a writer on methods of heating. "Indirect heating places the leaks out of sight, but they commonly lead to mischief, and require special and expensive provision for access and repair."

Professor Trowbridge.—"Steam heating involves greater first cost in apparatus than any other system. When its cost and the cost of attendance and repair are taken for a series of years, however, it is conceded that there is but little choice between hot-air furnaces and steam-heating apparatus as regards economy."

"When the method of heating is by direct radiation in the rooms, the advantages of steadiness of control, sufficient moisture and good ventilation are not always secured; but this is rather the fault of design, since all these requirements are quite within the reach of ordinary contrivances."

Looking over this evidence for and against furnace heating, and steam heating, the following prominent facts are made plain:

Furnace heating is cheapest in first cost. Outside of the matter of first cost, steam heating is decidedly preferable, where properly arranged. The element of danger is a very small consideration with the modern apparatus, and practically nothing if the boilers are out of the building.

The argument about noise and cracks in the pipes has very little value, in view of the fact that, as now constructed, a good apparatus gives no chance for water-hammer.

Furnace heating is practically limited in application to small houses. Beyond that, several furnaces are required, and steam heating becomes decidedly cheaper in cash outlay, year by year. Steam heating, on the contrary, can be, and readily is, economically applied to any size of building, from the house to an entire block, or more, and would probably prove cheapest for any but small houses, if, after a series of years, the yearly cost were considered in connection with the interest on the first cost.

Furnace heating being out of the question for large buildings, it remains to say that an honest difference of opinion may easily exist

regarding the relative convenience and ease of management of furnaces and steam-heating apparatus in houses. In view, however, of the modern automatic arrangements for draught, feed of fuel, etc., the efficient systems of steam and return pipes, the easier control of the temperature of the rooms, and the greater facilities for active ventilation, steam heating seems to be decidedly preferable for any houses above the medium size.

The open fire-place, which has been lost sight of in this discussion of more elaborate systems of heating, is mentioned by both writers as a most valuable adjunct in houses to either steam or furnace heating, supplementing them in very cold weather, and aiding the ventilation to a great extent.

Finally, it may be well to close with what are the concluding lines of Professor Trowbridge's article, viz.: "It should be regarded as a fundamental principle in architecture, that the first and most important problem to be studied, after the general design of a building is determined, is the proper positions and magnitudes of heating and ventilating appliances for the structure as a whole, and for each room in particular; and not only should the details of main and cross walls be modified and adapted to these arrangements, where necessary, but no question of mere architectural propriety or appearance, nor even of convenience in use, should be allowed to interfere with objects so important to health as good and sufficient warming and ventilation."

JAMES L. GREENLEAF.

CIVIL ENGINEERING.

Prof. Trowbridge and the Cantilever Bridge.—It is interesting to notice in connection with the much-talked-of Cantilever Bridge over the Niagara Rapids, that among the first men, if not the very first, in that new field of bridge-building was our present Professor in Civil Engineering, Prof. W. P. Trowbridge.

According to an interesting article in the *American Contract Journal*, the first design made in this country embodying the cantilever principle, was published by Prof. Trowbridge simultaneously with the appearance in England of Mr. Baker's book on "Long Span Railway Bridges," which involved the same principle.

The details of the design were arranged for the crossing of the East River at Astoria, an enterprise in which Prof. Trowbridge was at that time interested. With this design of Prof. Trowbridge as a basis, the New York and Long Island Bridge Company was organized, and later, in 1875, a committee was appointed to receive competitive designs. Of the ten or twelve designs submitted, the one finally accepted was made by Mr. Macdonald, now President of the Delaware Bridge Company. This design agreed in all but minor details with the one which Mr. Trowbridge had submitted to the Secretary of the Company before the creation of the committee, and which design had been extensively described and illustrated both in the New York *Tribune* and the Transactions of the Connecticut Academy of Sciences. Prof. Trowbridge did not enter into the competition, on account of lack of time.

The writer closes by emphasizing that the first accepted design was in effect that of Prof. Trowbridge, that the company calling for designs was itself founded on a plan of Prof. Trowbridge's, and that the plan of

applying the cantilever to large spans in American bridge-building, first crystallized into definite form in the mind of Prof. W. P. Trowbridge.

D. E. M.

The New Forth Bridge.—This structure will consist of two spans of 1,700 ft., two of 675 ft., 14 of 168 ft., and six of 50 ft., placed 150 ft. above high tide.

The two large spans are two cantilevers, each 675 ft. high, with a central girder 350 ft. long, the cantilevers being 350 ft. high at the piers, and 50 ft. in the centre.

The central pier will consist of four cylindrical masses of concrete and masonry 70 ft. in diameter at the bottom, tapering to 45 ft. at the top. The foundations go down from 24 to 70 ft. below high water, and the towers will be carried up 18 ft. above the level of the highest tides. The length of the bridge will be over a mile, and the viaduct approaches 2,754 ft. The estimated cost is $8,000,000.

The steel used will weigh 45,000 tons, and is to be manufactured into the different members on the spot, a large plant having been put up for this purpose. All important compression members will be of a tubular form; the bridge requiring about three miles of steel tubes ranging from 12 ft. to 5 ft. in diameter, and from 1¼ to 1½ inches in thickness.

The plates for these tubes will be heated in gas furnaces, stamped to the desired curvature by hydraulic power, the edges planed and the plates temporarily clamped together. A drilling machine which traverses the tube drills all the necessary holes; but the riveting will not be done until the bridge is being erected, plate by plate.

The plant necessary is being put up and the manufacture of the superstructure will soon begin.—*Railroad Gazette, Feb.* 1, 1884.

E. G. B.

Some New Developments in Fire-Proof Buildings.—In a building erected near Portchester, N. Y., Mr. W. E. Ward introduced composite beams and rafters, in which rolled iron beams (I beams or inverted T's) take the tension, and carefully mixed béton the compression strains. Tests on a beam 12 ft. long by 5″ x 12″ with a 4″ I beam in the lower flange (wt. = 30 lbs. to the yard) gave a deflection of $\frac{7}{16}$ inch with a central load of 9,500 lbs. There were no signs of failure, and the beam returned to its original line with no permanent set. The safety load of the 4″ I beam alone was limited to 1,150 lbs.

The composite beam is much more capable of resisting fire than the naked beam, which fails immediately after exposure to intense heat.

Upon these beams the floor was laid, a layer of paper being, however, interposed, so as to prevent the expansion and contraction of the floor affecting the beams.

The floor was built on the same plan of composite construction. Between the beams a false floor of thick board was placed flush with the upper surfaces of the beams. Upon this a 1-inch layer of concrete was spread and evenly tamped. Over this were laid rods of iron $\frac{5}{16}$″ in diameter, placed longitudinally and laterally at a uniform distance of 8″ apart. Over this network a final layer of 2″ of béton was carefully tamped. In eight hours the béton was sufficiently dry to allow a top surface of cement and fine beach sand mortar to be floated over. This finished the floor to a thickness of 3½″, when the false work below was removed.

A floor built in this way and supported by composite beams (18″ span, 7″ x 16″ section, with a 7″ I beam in lower flange weighing 55 lbs. to the yard) placed 6″ between centres, was tested with casks of plaster amounting to 30 tons, placed over one beam in a triangular load.

Partitions in like manner were built of 2½ inches of béton, reinforced with ¼-inch rods, and were shown by experiment to be equal in strength to 8-inch brick walls. Special tests of béton in the form of bricks showed the advantage of using small angular fragments of blue limestone in place of larger filling-stones. As to its qualities as a fire-proof material, severe tests gave satisfactory results, and the author concludes by claiming that the reinforced system gives great advantages in point of strength, cost, and fire-proof qualities over any other method of fire-proof construction. It also affords special advantages for the heating and ventilation of buildings.—*W. E. Ward, in Vol. IV. of Trans. Amer. Soc. of Mech. Eng.* D. E. M.

Crushing Tests of Building Stone.—In the selection of stone for the foundation of the chimney of the Edinburgh (Scotland) gas-works, a series of tests were made by crushing one-inch and four-inch cubes. The results obtained on Hailes stone from the one-inch cube were equivalent to 225 tons per square foot, while on the same stone from the four-inch cube the result was 567 tons per square foot. These results are of interest in connection with the suggested appointment of a government commission to test large structural pieces in place of the small test pieces usually employed.—*Am. Gas-Light Journal, Feb.*, 1884. J. B. M.

Mining Engineering.

Berg Nickel Mine, Senjen, Norway.—One of very few successful mines within the Arctic Circle is in the Island of Senjen, Norway, lat. 69° 26′ N. and long. 17° 15′ E.

On the northwest shore, 80 feet above sea level, is the Berg Nickel Mine. Through the country rock, a gabbro, is disseminated a nickeliferous pyrrhotite, which, after a rough sorting of the ore, yields 1 % to 4 % of nickel—average about 1.5 %—and small amounts of cobalt and copper.

The mine itself is an open working to a depth of 13 fathoms, while below this floors and pillars from 6 to 9 feet thick are left.

There are no definite limits to the width of the workings, but the paying ore runs from 24 to 40 feet wide.

The ore is treated for regulus at works near by in three operations:

1st. Fusion in blast furnace with slag and coke, giving "first metal."

2d. This is broken into small lumps and roasted in piles of 100 to 140 tons for four or five weeks. The product known as "burnt metal" is,

3d. Fused in a peculiar furnace termed "concentrator" with scorias, coke and granite, which is the only convenient source of silica.

The product of the operation is a regulus carrying from 22 to 30 % of nickel. This is shipped to Swansea, England, and there re-treated.

The mine and works have an abundant and powerful water supply. —*Trans.-Royal Geol. Soc., Cornwall.* S. S. F.

The Use of Tamping with High Explosives.—Mr. G. C. André, in a communication to the *Colliery Guardian*, mentions an interview with a

contractor who is running a drift through a strong rock, and who has reduced his charges of dynamite by one-third, getting the same effect with the use of clay tamping as when he used a larger charge and no tamping. The contractor stated that the prevailing opinion that the saving of time consumed in tamping the hole compensates the loss of a considerable quantity of explosive is erroneous. "Tamping with clay pellets, prepared by boys beforehand, occupies but little time, and the more complete combustion of the explosive, and the reduced quantity employed, lead to a diminished vitiation of the air, so that the men may return to work immediately after the blast is fired."

In another case of driving a heading in stone a saving of about 50 per cent. in cost of explosives has been effected by using dynamite in the strong holes and black powder in the rest, the proportion being one hole charged with dynamite to three with black powder. The rock is very hard and tough. S. S. F.

Pumping-Engines Under ground.—Mr. André, in his letter to the *Colliery Guardian* of January 18th, states that "the practice of erecting pumping engines under ground and conveying steam down from boilers at the surface, is everywhere gaining ground."

The most recent example he met with was at a coal mine at Saarbrücken, Germany. The depth from the surface is 260 yards, and height of lift to an adit or off-take 230 yards.

The steam-pipe is of cast-iron, $5\frac{1}{2}$ in. diameter, well covered.

The rising main is $9\frac{3}{4}$ in. Two engines are in place, each capable of lifting 330 gallons per minute; both are supplied from the same steam-pipe and throw into the same main.

The boiler-house on the surface and the engine-room below are in electric communication. S. S. F.

Mechanical Engineering.

Life of Car Wheels.—The Boston and Albany Railroad has kept a systematic record which throws some light upon the relative service of steel-tired and chilled cast-iron wheels under passenger cars.

During 1883, 180 Hartford steel-tired wheels have been removed as worn out. Their average mileage has been 245,980 miles, the minimum being 63,500 and the maximum 470,000 miles; average time in service 7 years, 8 months and 3 days. Out of 180 wheels worn out, 131 ran over 200,000 miles, and only about three per cent. of the total number ran under 100,000 miles.

The average mileage of worn-out cast-iron wheels removed during 1882 was 29,074 miles, showing that one steel-tired wheel will outlast eight chilled wheels. The latter ran on an average only 332 days.

The total cost of one pair of steel tired wheels, with interest and cost of changing and turning, to run 245,980 miles, has been, less scrap wheels	$148 35
Cost, etc., for iron wheels for same distance.....	190 31
In favor of steel-tired wheels.....	41 96
Cost of steel-tired wheels.....	88 25
Cost of cast-iron wheels.....	140 52
Difference in favor of steel-tired wheels.....	52 27
Difference in favor of the 180 steel-tired wheels removed during the year, with interest, etc., added..	3,776 40

The average weight of the cars in service is 40,522 lbs.; size of wheels 33 in., four wheel-trucks, sharp curves and heavy grades, with quick stops and the automatic brake tending to damage the wheel.—*Read by John M. Ford at meeting of the Master Car-Builders' Club, Boston, Jan.* 30, 1884. E. G. B.

Economy by Subdivision in Engine and Boiler Plants.—The highest economy in steam generation takes place when the combustion is most perfect, and therefore for perfect economy the temperature of the fire should be kept nearest to this point. From boiler tests on best constructed boilers it may be assumed that highest economy is reached when 9½ lbs. of anthracite egg coal per sq. ft. of grate is burned, producing 3¼ horse-power.

This gives the ratio for best subdivision of boilers to suit engines.

Steam engines, built for a certain maximum capacity, naturally show at full service their maximum economy. The loss by friction remains practically constant from minimum work to full capacity. This and other causes make a small engine working at its maximum efficiency more economical than an engine of twice its maximum capacity doing the same work. The author gives a diagram showing percentage of loss for two engines whose maximum capacities are as 1 to 2, the engines doing the same work.

The two curves show a difference of about 20 per cent. in favor of the smaller engine. The loss per cent. in working at anything less than maximum capacity as derived from the curves is 20 per cent. for using a machine at ½ capacity; 34 per cent. for using a machine at $\frac{3}{10}$ capacity; 54 per cent. for using a machine at $\frac{3}{20}$ capacity.

The example given was derived from several systems of indicator diagrams, and had especial reference to engines used for electric lighting. The general results are, however, applicable to all prime movers.—*Julius L. Hornig, in Vol. IV. Trans. Amer. Soc. Mech. Eng.* D. E. M.

A torpedo boat built by Thornycroft and Co. for the Russian Government, on a special trial steamed 103.8 knots in 9 hrs. 20 min., on a few pounds less than a ton of coal. The boat measures 113 ft. on water line; beam, 12 ft. 6 inches; depth, 6 ft. 6 inches; draught forward, 2 ft. 6 in.; aft, 6 ft.; displacement, 60 tons.

In a three-hour test the mean speed allowed was 18.97 knots, boiler pressure, 129.5 lbs., vacuum 24.16 inches, revolutions per minute 404. The mean speed attained in 6 runs of 1 knot each was, 19.506 knots per hour. Boiler pressure 130 lbs., 413 revolutions per minute, with 17.13 per cent. slip of screw.—*Engineering* (*London*), *Dec.* 28, 1883.

D. E. M.

Paper gas-pipes are made from hemp paper, which has been dipped in melted asphalt, and then tightly rolled on a core until the desired thickness is obtained. The tube is then put under pressure and cooled with water, sand having been sprinkled on the outside. After the core is withdrawn, the interior is treated with waterproofing solution. These pipes are cheaper than iron, and are absolutely tight and smooth. Pipes which are three-fifths of an inch thick will stand a pressure of more than fifteen atmospheres. They are not broken by heavy jarring and shaking, and hence can be safely used under pavements in the streets.—*Journal of Gas and Sanitary Engineering, Jan.* 1, 1884. E. G. B.

METALLURGY.

Improvements in the Basic Bessemer Process.—The following resumé is from London *Iron*, of July 22d: Steel-making from phosphoriferous pig-iron seems to make rapid strides on the continent, for we hear that new Bessemer works are under construction at Ars-on-the-Moselle, in Lorraine, and at Völklingen, near Saarbrücken, both of which are intended to make steel from the cheap "minette" iron ore, a description of ore resembling much the Cleveland oolitic limestone, and which is found in enormous deposits in Luxemburg and Lorraine. When the basic process, with a converter lining of dolomitic bricks, was first introduced, the Rheinische Stahlwerke, at Ruhrort, and the Hörder Berg- und Hüttenverein were not slow in appreciating its value and in securing the patent rights for the German Empire. Though the validity of the patents was energetically contested by a combination of German iron-masters, the patentees succeeded, nevertheless, in overriding all opposition in the various law courts where the matter was to be decided. The first step was the introduction of basic bricks for converter linings, instead of the usual ganister, or fire-brick lining; the second, that of the addition of basic fluxes in combination with a prolonged after-blow, after the elimination of silicon, carbon, and manganese from the metallic bath. It was then considered essential that the basic cinder should contain from 36 to 40 per cent. of lime and magnesia, and only from 8 to 20 per cent. of silica, and that the fluxes added to the metal should be—first, a mixture of about 9 parts lime and magnesia with one part red oxide of iron; and secondly, after a blow of from six to ten minutes, a mixture of 2 to 3 parts of lime with one part of oxide of iron, such as red hematite. The admixture of oxide of iron proved the more necessary the less the quantity of manganese in the pig-iron, and whenever the same was very large it could be left out altogether. It is now well understood that the phosphide of iron only begins to be decomposed after all the silicon and carbon have disappeared; that is, after the characteristic carbon lines have completely disappeared in the spectroscope; and that its decomposition requires after-blowing for several minutes, when only the oxidized phosphorus will combine with the bases of the flux, chiefly with its lime and oxide of iron, which combination is accompanied with a voluminous emission of brown smoke, caused by burning iron. After the removal of the phosphoriferous cinder, spiegeleisen was then added, in order to reduce any oxide of iron which was dissolved in the fluid metal, and besides to dose it with sufficient carbon for becoming ingot iron, mild steel, or hard steel, as required. This mode of procedure was the usual one with gray phosphoriferous pig-iron; the after-blow has, however, some inconveniences, which consist in the loss of metal and the greater amount of time. The Rheinische Stahlwerke have therefore tried to replace the after-blow by another oxidizing reaction, and to employ combined oxygen instead of free atmospheric oxygen for the elimination of phosphorus. The bearers of combined oxygen are the oxides of iron and manganese, which are introduced either in the solid or in the molten state, and intimately mixed with the metallic bath. The quantity of oxides is determined from that of phosphorus, and their oxygen ought to contain as much as 25 per cent. more than the free atmospheric oxygen which would have to be blown in the metal if it were to be finished by the usual after-blow.

The basic process has been in successful operation at Ruhrort since September 22, 1879, as well as at Hörde. Licenses to use the patents, which were partly acquired from Mr. S. G. Thomas, partly taken out independently, have been granted in Germany and Luxemburg to the following iron and steel works, namely: Gebrüder Stumm, of Neunkirchen; the Dillingen Iron Works, near Saarbrücken; Gebrüder Genauth, of Kaiserslautern; Messrs. Les Petits fils de Fois de Wendel & Co., of Hayange; Messrs. De Dietrich & Co., of Niederbronn; the Burbach Iron Company, the Rothe Erde Iron Works, of Aachen; the Lothringen Iron Works, of Ars-on-the-Moselle; the Maximilianshütte, of Regensburg; and the Bochum Steel Works.

It appears that, beside the Bessemer converter, the dephosphorizing process makes favorable progress in the open-hearth furnaces as well, when basic fluxes, such as lime, dolomite, oxide of iron, and manganese are employed. Among their number reappears the fluoride of calcium, fluor spar, or "cand" of the Cornish miners, which was patented some fifteen years ago by the late Prof. Theodor Scheerer, of the Bergakademie, of Friburg, Saxony, for the purpose of dephosphorizing iron in the puddling furnace. When fluoride of calcium was tried at the Hörde Works, at the instance of Prof. Scheerer, it was found that other combinations of lime, when in a fluid state, would react on the phosphorus as well; for instance, chloride of calcium, and also chloride of magnesium, though they are liable to be decomposed into chlorine and lime or magnesia by heat alone, while for the decomposition of fluoride of calcium the presence of silica is essential. All these fluxes will, of course, act as well in the Bessemer converter; and as fluoride and chloride of calcium form a very thin and fluid cinder, they seem to be far better suited for the washing out of phosphorus from the metallic bath than caustic lime or magnesia, or a mixture of both, which do not melt, and therefore come very much less in contact with the particles of phosphide of iron which are to be decomposed than a more fluid substance. T. E.

Separation of Metals by Electrolysis.—A process for separating gold, silver and copper in alloys was lately shown in England. The alloy attached to the positive pole was suspended in dilute sulphuric acid contained in porous vessels, which were immersed in a solution of sulphate of copper containing copper plates attached to the negative pole. The electricity was furnished by two Gramme dynamos assisted by accumulators. Under the action of the current the copper and silver go into solution as sulphates, an equivalent amount of copper being deposited on the copper plates, while the gold set free falls to the bottom of the porous vessel, from which it is removed. When the solution in the inner vessel is saturated with the sulphates of copper and silver, it is run into a tank containing sheets of copper, which precipitate the silver in the metallic state, leaving only sulphate of copper in solution. The silver is removed, and the copper solution flows into the outer vessels as required. The sulphuric acid is used over and over again, and the metals are separated in a perfectly pure state. The process is almost automatic, is free from acid vapors, and economical; and instead of having to deal with the by-product, sulphate of copper, only metallic copper is produced.—*Iron Age.* T. E.

New Method of Making Chrome Steel.—Arthur Armitage of Sheffield, Eng., has invented a method of making chrome steel which gives it

greater hardness, toughness and ductility than is ordinarily obtained. He puts from one to two per cent. of chromium into the molten metal, either as manganiferous chromeisen or chrome spiegel, or both, depending on the amount of silicon and graphite in the alloy. This alloy is made by smelting in the blast-furnace mixtures of manganiferous and chrome iron ores, with lime and alumina compounds, and an excess of maganese, so as to produce a highly basic slag, and thus to prevent loss of chromine. If the product is manganiferous chromeisen, it is mixed with pig-iron and melted, and the mixture made into steel in the usual way. The manganese is expected to prevent the oxidation of the chromium during this process. If the alloy contains so little silicon and graphite as to be uninjurious if added directly to the molten metal, it may be used alone or mixed with ferro-manganese or spiegel, either solid or run into the converter furnace after melting, and oxidation will be avoided, and most of the chromium will be found in the steel.—*Iron Age.* T. E.

A New Form of Open-Hearth Steel Furnace.—A patent has been obtained by C. M. Ryder, of Chester, Pa., for a furnace for foundry use whose object is to allow the metal to be drawn from the bath in any required quantity. The method of removing the hearth allows not only of easy repair, but also of introducing large imperfect castings without breaking them. A slag skimmer is used to remove the slag before casting the metal; also a metallic shield to protect the workmen. The most important change is the raising and lowering of the movable hearth, by which perfect control of the quantity of metal allowed to flow out is given.—*Iron Age, Dec.* 27, 1883. T. E.

Manganese Bronze.—This alloy has such remarkable wearing qualities that its use is greatly increasing. A small amount of ferro-manganese is melted in a separate crucible and mixed with the copper. The manganese, having an affinity for oxygen, cleanses the copper of oxides by combining with them and rising as slag. Part of it combines with the copper, and increases the strength, hardness and toughness of the bronze and brass made from it. The British Manganese Bronze and Brass Company use it for propeller blades, and claim that they can be made thinner than when constructed of steel, because, being non-corrosive, no allowance is given for pitting. The cost is greater, but as they last eight years while the steel ones last only three, they are cheaper in the end.—*Iron Age.* T. E.

Heat Developed in Forging.—M. Tresca, of Paris, has recently made some experiments on the production of heat by the blow from a steam-hammer. The faces of the hammer and the anvil were exactly alike, and the blows fell upon a carefully polished bar, covered with a thin layer of wax.

M. Tresca, sums up his results as follows:

1. The development of heat depends on the form of the faces and the energy of the blow.

2. With faces having sharp edges, this heat may be clearly indicated.

3. The heat is greatest where the shearing is greatest. This is therefore the mechanical cause that produces the heat.

4. With a blow of sufficient energy, and a bar of sufficient size, 80 per cent. of the energy appears in the heat.

5. The figures formed by the melted wax give a diagram showing the distribution of the heat and the character of the deformation of the bar.

6. Where the energy is small, the calculation of the percentage is not reliable.

These conclusions refer to anvils and hammers having sharp faces. Where the faces are round, the phenomena are somewhat different.—*Iron Age.* T. E.

Improvements in Coke Ovens.—Mr. Henry Simons has recently made some improvements in the Simon-Carvé cake ovens. With these ovens the coking is claimed to be more economically done; and the products of distillation are collected in such a way as to be of use. Mr. Simons' improvements effect a still greater economy in fuel by the regenerative system, causing the waste heat to be utilized; by applying it to the gas or air used for combustion, or by heating retorts for gas manufacture, steam boilers, ovens or furnaces for glass and keramic ware. A chimney draught is sometimes sufficient to produce the necessary currents, sometimes an exhaust or blowing fan is required. The apparatus to heat the gas or air may be raised to the required temperature by the gaseous products of the furnaces, or by the heat produced in the coking process. The furnaces burn either solid or gaseous fuel. Several English collieries are now using these improvements, and others are making arrangements to do so.—*Iron Age.* T. E.

Dense Metal Castings.—A new process for eliminating the gases from steel castings has been patented in England. This is done by subjecting the molten metal to centrifugal force in a vacuum. The centrifuge is a cylindrical wrought iron shell, open at the top, 3 feet in diameter and 18 inches high. A rim 18 inches wide surrounds the opening; the whole is lined with refractory material, or may be entirely composed of it. The shell rests on a wrought iron shaft 3 ft. high, to which it is riveted, and which rests on its conical shaped end in a hole in a steel plate, so as to turn easily. A foot above the pivot a driving pulley is connected with the motive power. To make it last longer the shell is surrounded with an iron jacket, with an inch space between, which is filled with cold water, introduced through the hollow shaft, and forced up from the lower end, where it works in the socket. The hot water runs out through the holes made in the outer shell which are continued through the solid refractory brickwork which surrounds the whole. The apparatus is closed by a wrought iron cover bolted to the brickwork and air tight. A two-inch hole is left in the cover, which carries a funnel from which a tube of refractory material extends into the centrifuge. Another hole in the cover connects with an exhauster to remove the air and the separated gases. The inside of the apparatus is first heated by a blast of gas and air. The exhauster at the same time draws off the products of combustion. The blast is then stopped and the centrifuge rapidly rotated. The molten metal is poured into the funnel, completely filling the pipe, thus excluding air. On reaching the bottom of the shell it is driven toward the sides and spreads over them in a thin sheet, and gradually rising on the sides, it overflows the rim, and runs into a channel on the brickwork, from whence it flows continuously. The inflow is regulated by the outflow, and both are controlled by the speed of the revolution. The operation being con-

tinuous, the apparatus need not be large. Another apparatus, in which the centrifugal action is assisted by a vacuum produced by it, has a circular table on the upper end of the vertical shaft. A prism, with one or more perforations through its entire length, is fastened across it. A funnel placed in the centre of the prism communicates with these radical perforations, its outlet being smaller than the sections of the perforations taken together. In working, this funnel is always filled with molten metal to exclude air. The table is rotated rapidly, and produces a sucking action at the openings of the channels in the prism, forming a vacuum at their centre; the metal passing through them is broken up and the gases escape. The metal on reaching the table is thrown against the surrounding brickwork and broken up, and the remaining gases escape. All parts of the apparatus are lined with refractory material, or made entirely of it. It may be made movable and filled directly from the converter or the casting ladle. The prism is heated by introducing a hot blast through the funnel. Four revolutions a second are sufficient with a rotating table 2 ft. in diameter. The power may easily be furnished by four men.—*Iron Age.* T. E.

Improvements in Casting Pits.—Gjers has improved his casting pits so as to still further secure the top of the ingot in the pit from becoming cooler than the rest. The pit has an inner and an outer cover. The inner one is a little above the top of the ingot, and when an ingot is removed the covers are replaced, and thus the inner one is kept hot, and will not afterward have a cooling effect on the top of the ingot. The space between these covers may be filled with non-conducting material, thus helping to keep the pit at a high temperature. In some works, instead of two covers, the cover is a mass of brick suspended from a metal cover. The pit walls are liable to become injured by the heat and by abrasion. To repair them without the delay of cooling, an iron box, having the shape of the cross-section of the pit, the sides at the upper part forming a pyramid, is attached to a crane by which the apparatus is lowered into the pit. Some suitable refractory material is thrown on it and guided into position by the sloping sides of the apparatus and rammed into the recesses of the walls, the apparatus being moved upward by the crane as required.—*Iron Age.* T. E.

New Method of Ingot Casting.—A new method for producing ingots free from bubbles has been suggested in England, by placing the mould with the large end up, giving the gases more room to expand and escape. To remove the ingot from the mould two slots opposite each other are cut in the inside of the large end of the mould and fitted with movable slide pieces or filled with sand or clay. The mould is filled with metal above the bottom of the slots; when cool the slide pieces or clay are removed, the tongs inserted in the spaces, and the ingot lifted out. If this method proves to be efficient it will soon be put in practice.—*Iron Age.* T. E.

ELECTRICITY.

Underground Electric Conductors.—The American Bell Telephone Company has recently put down two lines of underground wires in Boston, from which it estimates the cost of an underground system as follows: Eight wrought iron pipes, three inches in diameter, are laid

side by side in two rows, about four feet below the surface. At each street corner is a man-hole with a cover flush with the street.

The cables, of which several kinds are in use, run through these pipes, up the sides of houses, and then spread out by means of ordinary lines.

The cables cost from $60 to $150 per mile for each circuit, according to the kind of cable used. The cost of piping, etc., is $50,000 per mile, the system accommodating one thousand wires. In round numbers one thousand wires cost $150,000 per mile, or $150 per mile for each conductor. To carry only one hundred wires the expense is nearly the same, so that the system is not economical except where a large number of wires can be laid in one trench.—*Dr. Wm. W. Jacques, Electrician of the American Bell Telephone Co., in Popular Science Monthly, Feb.*, 1884, p. 503. E. G. B.

Silicious Bronze Telegraph Wires.—From recent information quoted by the London *Engineering*, the silicious bronze invented by M. Lazare Weiller seems likely to take the place of much of the steel and iron wire now used. A table given shows the tensile strength, resistance per mile and conductivity compared with other wires now in use.

DESCRIPTION OF WIRE.	TENSILE STRENGTH PER SQUARE INCH IN TONS.	RESISTANCE PER MILE IN OHMS.	RELATIVE CONDUCTIVITY.
Pure Copper	17.78	33.1	100
Silicious bronze (telegraph wire).	28.57	34.5	96
Sllicious bronze (telephone wire).	48.25	103	34
Phosphor bronze (telephone)	45.71	124	26
Swedish galvanized iron	22.86	216	16
Siemens-Martin steel	26.67	266	12
Galvanized Bessemer steel	25.40	249	13

In regard to the important element of cost, an estimate for a telegraph line of 1,000 kilometers (621 miles) is given, by which a total saving (in cost of wire, posts, carriage, etc., etc.) over an ordinary line of same length, amounting to 30 per cent. is indicated, with, moreover, an increase of 100 per cent. in conductivity and equal tensile strength per square inch of section.

The wire can be drawn in very great lengths, and the number of joints are diminished greatly. The following table gives a statement of a few of the qualities of the wire :

TELEPHONE WIRES.

DIAMETER M.M.	SECTION IN SQUARE M.M.	RESISTANCE IN OHMS PER MILE.	WEIGHT PER MILE IN POUNDS.
1.0	0.7854	103	24.6
1.25	1.2252	64	38.5
1.40	1.5393	51	48.3

TELEGRAPH WIRES.

1.25	1.22	22.5	38.5
1.50	1.7671	15.6	55.6
2.00	3.1416	8.8	99.2
3.00	7.0685	3.9	223.
4.00	12.5664	2.4	396.
5.00	19.6349	1.4	620.

—*Engineering* [*London*], *Nov. 23d*, 1883. D. E. M.

CHEMISTRY.

Extraction of Native Sulphur.—The deposits of native sulphur are of two kinds, those of recent volcanic origin and stratified formations, associated with marly and bituminous limestones, gypsum, celestite, etc., these latter forming the most important sources.

In Sicily and Italy the deposits are mined in a very primitive fashion, the extracted mineral being carried on the backs of the miners to the surface. The sulphur is generally extracted by burning one portion in order to obtain sufficient heat to melt the rest. As the sulphurous acid formed is very destructive to vegetation, this operation is only conducted during the first six months of the year.

The furnace in which this is effected, called a *calcarone,* is of circular section, the bottom being inclined toward the tap-hole. The ore is placed in it, flues being left in which sticks and brushwood are placed, and the top is covered with fine material containing no sulphur. The product obtained is from 50 to 60 per cent. of the sulphur contained.

This process being very imperfect, several plans have been tried to save more of the sulphur at less cost. Hot furnace gases and superheated steam to melt the sulphur, and bisulphide of carbon to dissolve it, have been tried, but the first is too slow and irregular, the second too expensive, while the third, theoretically perfect, is both dangerous and expensive.

The employment of saline solutions boiling above the melting point of sulphur, as a means of extraction, was proposed in 1805 by M. Thomas; in 1867 Ballard, and in 1868 Dépérais proposed magnesium and calcium chloride solutions respectively. From various causes, however, these methods have not been practically successful until quite recently, when Messrs. de la Tour Dubreuil have perfected the process.

They use a solution of calcium chloride boiling at 120° C. The cost of calcium chloride delivered at the works is only 9 francs per 100 kilos, and as the solution is used over and over again, the expense on this account is very small.

The apparatus used consists of two sheet-iron vats, 2 metres long, 1.30 wide and 0.75 high. The bottom is traversed from end to end by a wide gutter inclined toward the end, from which the sulphur is tapped. The sides of the gutter are protected by vertical gratings of sheet-iron, with interstices of 3 mm. width, the iron being 2 mm. thick and 25 mm. wide. These serve as filters to keep back the fine mineral portions of the charge.

These vats are alternately heated from a fire-place between them below, in such manner that while a charge is being treated in one, the other one is being emptied and re-charged. When the sulphur no

longer flows out when tapped, a stop-cock connecting the two vats is opened, allowing one-half the solution to flow into the fresh charged vat; the rest is drawn off into a reservoir and pumped into the vat. The exhausted charge is rapidly washed, to remove the liquor remaining, and this wash water is used to replace that lost by evaporation. Each charge requires two hours' treatment. As the solution is used continuously, there is but little loss of heat. The sulphur obtained only contains from one to two thousandths impurity. The gangue retains 4 to 5 per cent. sulphur.

This method utilizes the fine material formed by breaking the ore to suitable size. This material, though much richer than the average ore, is called *sterro*, it having been impossible to treat it in the calcarone. The expense of extracting one ton of sulphur from a 33 per cent. ore is estimated at 12¾ francs.

The advantages offered by this method are:

1. Nearly perfect extraction, with the use of little fuel and cheap material.

2. Extraction uninfluenced by the condition of the weather.

3. Non-formation of sulphurous acid, rendering it possible to work during all the year.

4. Easy adaptation to commercial considerations.—*M. Camille Vincent, Bull. de la Soc. Chim. Dec.*, 1883. J. B. M.

Use of Fluorhydric Acid for Decomposition of Samarskite and Allied Minerals.—The late J. Lawrence Smith, in a paper upon the "Methods of Analyzing Samarskite and the other Columbates," * * * etc., mentions the ordinary method of decomposing these minerals by means of potassium bisulphate, or, better, acid potassium fluoride, both of which are objectionable, however, as affording incomplete decomposition, and introducing large amounts of solid matter into the analysis. The use of fluorhydric acid completely obviates both these difficulties. It has been employed with success in the decomposion of all the columbates, as samarskite, euxinite, fergusonite, etc., and also in decomposing columbite and tantalite. These latter require very fine pulverization before treatment. In the analysis of samarskite, the finely powdered mineral is placed in a small platinum dish, moistened with water, and concentrated fluorhydric acid gradually added, with stirring. For 5 gms. of this mineral, 8–10 c. c. of the acid is sufficient. Decomposition is rapid and complete, as shown by the disappearance of every black particle in the mass. As a result of this treatment, there is obtained a colorless solution, containing all the metallic acids, with oxides of iron and manganese, and a heavy green residue, consisting of all the earths and uranium oxide. The solution is filtered from the residue; the metallic acids are rendered insoluble by evaporation with sulphuric acid and subsequent dilution and boiling, and are thus separated from the iron and manganese, which remain in solution. The residue is brought into solution by treatment with concentrated sulphuric acid; this is diluted, the uranium oxidized by means of nitric acid, the solution nearly neutralized with ammonia, and the earths precipitated with oxalic acid, or ammonium oxalate, leaving the uranium in solution. It is worthy of note that in all these operations no solid matter is introduced by the reagents used. The various constituents are afterward separated and estimated by known methods.—*Am. Chem. Jour., Vol. V.*, p. 44. A. L. B.

A new Residual Product from Coal Gas.—In a paper read before the Society of Chemical Industry, by Mr. H. Leicester Greville, a process is described for obtaining carbon disulphide from the spent lime of the purifiers. The crude gas of the Commercial Gas Works, London, where the process is in use, contains per 100 cubic feet, about 1,000 grains of sulphureted hydrogen, 1,000 grains of carbonic acid, 240 grains of ammonia, and from 30 to 48 grains of sulphur in organic compounds, chiefly carbon disulphide. After the removal of the ammonia, the crude gas is passed into the ordinary purifiers, which are charged with a mixture of lime and oxide of iron in such proportions that the lime will combine with all the carbonic acid, and the iron with all the sulphureted hydrogen. It is important that the carbonic acid be completely removed, as it, if present, would interfere with the next operation. The gas now will contain only the organic sulphur, averaging 30 grains. To remove this a special series of purifiers is used. They are charged with lime and saturated with sulphureted hydrogen, transforming the lime into sulphide of calcium. The crude gas, from which all the ammonia and carbonic acid, and *part* of the sulphureted hydrogen have been removed is used to furnish the sulphureted hydrogen needed. When these purifiers, or *sulphur vessels* as they are called, are thus prepared, the partially purified gas coming from the ordinary purifiers passes through them, the carbon disulphide being absorbed, forming calcium sulpho-carbonate or some compound of more complex character.

The contents of the sulphur vessels, when saturated, are of a bright orange-red color. When this substance is distilled with water it is decomposed, carbon disulphide distilling over, and a residue, consisting largely of lime, being left behind.

The analysis of carbon disulphide is conducted as follows: A flask containing an alcoholic solution of potash is weighed, and the carbon disulphide dropped in from a pipette. Being heavier than the alcoholic solution, it sinks at once to the bottom, and there is no fear of loss by evaporation. After weighing the flask again and agitating to dissolve the carbon disulphide and transform it into xanthate, the dilute solution is treated with a slight excess of potassium permanganate. Hydrochloric and oxalic acids are then added to redissolve the precipitated manganese binoxide, and the sulphuric acid estimated as barium sulphate. The figures given by the author are very satisfactory for the accuracy of the method.—*American Gas-Light Jour.*, *Jan.*, '84. J. B. M.

Preparation of Oxygen from Air.—The air is drawn through a series of diaphragms composed of cloth soaked in alcohol or carbon disulphide and thin films of caoutchouc. The oxygen diffuses through these diaphragms so much more rapidly than the nitrogen, that after passing the fourth one the amount of nitrogen was reduced to 5 per cent.—*Zeit. für Anal. Chemie*, 1884, p. 59. J. B. M.

For the Rapid Estimation of the Fatty Acids and Alkali in Soap, Pinchon employs a burette with a glass stop-cock below and a stopper above. In this, 5 c.c. normal hydrochloric acid and one gram of soap in thin shavings, with 10 c.c. ether, are introduced, and the burette shaken until the decomposition is complete. The watery solution is drawn off and the ether washed till free from acid. By titrating with normal alkali the amount of alkali in the soap is determined. The ether solution is

evaporated at the ordinary temperature, and the residue of fatty acids dried and weighed.—*Zeit. für Anal. Chemie*, 1884, p. 100. J. B. M.

The Estimation of Chlorine, Bromine, and Iodine in Presence of one another.—The mixed silver salts, after having been dried (not fused) and weighed, are dissolved in about thirty times the weight of water by the addition of the least possible quantity of potassium cyanide. Sufficient potassium bromide is now added to convert all the chloride of silver possibly present (i.e. the weight of the original precipitate) into bromide. The cyanide is now decomposed by the addition of an excess of dilute sulphuric acid. The precipitate of silver iodide and bromide is again collected, dried and weighed.

It is once more dissolved as before, and about one and a quarter times the weight of the original precipitate of potassium iodide is added, and the cyanide again decomposed by sulphuric acid. The precipitated silver iodide is now weighed, and from the three weights thus obtained, the amounts of the halogens present may be easily calculated. *F. Maxwell-Lyte, Chem. News, Jan.*, 1884. J. B. M.

Determination of Iodine in Mixtures of Iodides, Bromides, and Chlorides (*A. Cavazzi*).—The author adds to the solution of the haloid compounds, ferric sulphate containing no free acid. On boiling, the iodine alone is liberated, and may be absorbed in a solution of potassium hydrate, to be determined in the usual manner. He also recommends the use of a solution of ferrous sulphate in dissolving the ferric sulphate.—*Chem. News, Vol.* 49, p. 14. C. McL.

The Occurrence of Carbon in Phosphorus has been noticed by Ira Remsen and E. H. Keiser in the course of an investigation on the conduct of moist phosphorus and air toward carbon monoxide.—*Am. Chem. Jour.*, Vol. V. p. 424. J. B. M.

The Estimation of Tannin in Barks and Extracts.—Twenty grams of the bark are digested with distilled water for 15 minutes, and the partially exhausted bark retreated a second time in the same way. The two solutions are concentrated to 100 c.c., brought to 70° C. and titrated with a standard solution of albumen as long a precipitate is formed. The solution is now boiled and a standard solution of aluminium sulphate added with constant stirring until the precipitate becomes granular and separated from the solution. After cooling, the precipitate is collected on a weighed filter and washed with hot water. The weight of the precipitate, less the weights of albumen and aluminium sulphate added, gives the amount of active tannin present. The albumen solution is made by dissolving 20 grams to obtain 100 c.c. of solution, and the sulphate of aluminium solution by dissolving 10 grams in the same amount.—*M. Perrel, Bull. de la Soc. Chim.*, 1884, p. 22. J. B. M.

Fractional Separation of Selenium and Tellurium (*Masachika Shimosé*).—Mr. Shimosé states that if sulphur dioxide be passed into a hydrochloric acid solution of oxidized selenium and tellurium, the selenium will first be completely precipitated. As the selenium precipitate is light colored, while that of tellurium is black, he was able to effect an approximate separation by stopping the operation as soon as the

tellurium began to precipitate, and filtering off the selenium.—*Chem. News, Vol.* 49, *p.* 27. C. McL.

Volumetric Determination of Mercury (*Gustav Kroupa*).—Mr. Kroupa's method depends on the double decomposition which takes place when mercurous chloride and sulphureted hydrogen react upon each other. From the amount of hydrochloric acid formed, which is determined by titration with silver nitrate, the mercury may be calculated. The reduction of mercuric compounds is effected by means of ferrous sulphate and potassium hydrate, sodium chloride being added, if there is no hydrochloric acid in the solution. On the addition of sulphuric acid the precipitated ferrosoferric oxide is dissolved, while the mercury is filtered out in the form of mercurous chloride. This precipitate is treated with sulphureted hydrogen. The hydrochloric acid is neutralized with barium carbonate, while the excess of hydrogen sulphide is removed by adding zinc sulphate; after filtration, the solution is ready for titration.—*Chem. News, Vol.* 49, *p.* 14. C. McL.

SCHOOL OF MINES NOTES.

SCHOOL OF MINES CHEMICAL SOCIETY.—The officers for the second term are as follows:

President—C. S. McLaughlin. *First Vice-President*—F. J. H. Merrill. *Second Vice-President*—R. G. Rood. *Secretary*—J. F. Carter. *Treasurer*—E. Luttgen.

Since the last notice, meetings have been held as follows:

January 18, 1884.—A regular meeting of the Society was held at the School of Mines. The President, Mr. Burritt, was in the chair, and twelve members were present. Mr. R. Van A. Norris was duly elected to active membership. The Society then proceeded to ballot for officers for the ensuing term, with results as given above.

January 25, 1884.—A special meeting of the Society was held at the School of Mines, to listen to Mr. Moeller's paper on "The Lake Superior Copper Region."

The paper was amply illustrated with diagrams and mineral specimens; and was heartily appreciated by the members present.

At the close, a vote of thanks was given to Mr. Moeller.

ENGINEERING SOCIETY OF THE SCHOOL OF MINES.—Since the last notice, meetings have been held as follows:

January 11, 1884—Lecture: "Incandescent Electric Lighting," with lantern views, by Prof. F. R. Hutton.

January 18, 1884—Papers: "Vulcanized Rubber," W. Newbrough. "Engineering Experiences in the Northwest," H. N. Pierce.

February 15, 1884—Lecture: "The Unknown and the Unknowable as Factors in Scientific Conclusions," by Prof. J. S. Newberry.

In the lecture on Electric Lighting, views of different lamps, dynamos, etc., were thrown on the screen and explained by the lecturer.

Views of the old-fashioned, clumsy-looking lamps, which were first used by the companies, were compared with pictures of the latest improved, graceful lamps now in use in so many places in this city.

The various fanciful shapes which the carbon filament is made to assume, were pictured, and the good and bad points of the lamps explained.

Pictures of some of the type dynamos were shown, and the details, method of mounting, etc., of the machines, explained.

Prof. Hutton ended by exhibiting and describing the apparatus for measuring the amount of electricity used, in which a lamp prevents freezing of the liquids in the glass jars in cold weather.

In the lecture on the Unknown, Prof. Newberry spoke of many facts which are not satisfactorily accounted for by any theories yet advanced. He mentioned gravitation, light, spectrum analysis, meteorites, etc., as the means of our imperfect knowledge of the celestial bodies. The nebular hypothesis of La Place was explained, and some possible discrep-

ancies between the theory and actual existing circumstances were indicated. The fact that we have yet discovered no limits to the universe was pointed out. Various theories in regard to the maintenance of the solar vitality, the unknown composition of comets, the lack of an explanation of the solar corona, and the divisibility of matter were commented upon. An atom is one two-millionth part of a millimetre, and two million millions of them weigh a milligramme.

Prof. Newberry discussed the arguments in favor of and against Darwinism. E. G. B.

The Proposed Summer School of Surveying.

Information has just been received that the Trustees of the College have been memorialized in reference to the overcrowding of the studies in the third year of the course, and have taken action accordingly. While some details remain yet to be settled, the main feature of interest which has been established is what may be called a "Summer School of Surveying." It is proposed that the field work in surveying hitherto carried on in the afternoons of eight weeks in the autumn and of seven weeks in the spring, be all relegated to an interval of six consecutive weeks in the vacation between the second and third years. These six weeks can most conveniently be the weeks immediately preceding the opening of the fall session, giving two weeks in August and the four of September. The advantages of this plan are very considerable. By giving long hours, there is less loss by "crop-ends" of time frittered away in transit from college to surveying field. More repetitions and better drill are possible where but one kind of work is on hand and all attention is directed to one end. The Professor of Surveying can also be assisted by subordinate officers employed for a limited time, securing better supervision over the squads than by the present plan. Other points might also be advanced. But the disadvantages must also be noted. The class is brought back six weeks before school opens; it has no legalized organization, and not only proficient students but also delinquents must be on hand for instruction. Discipline may be difficult among such a band, and examinations will interfere with some. For non-resident students an extra expense for board and transportation is entailed. No lectures on the subject in the school concur with the field work, and thereby it is made necessary that the Professor repeat his instruction to individual squads on the ground as often as there are squads to be instructed.

But while further discussion of this topic may be better in place elsewhere, yet it seems unavoidable that one consequence of this legislation be a change, if not a cessation, of the work of the summer class in Mechanical Engineering, which has been so much approved. This latter occupies five weeks in the beginning of the same summer, and is voluntary. The surveying will occupy six weeks in the close of that summer, and is compulsory. If any work is done on a mechanical memoir, there is practically no break in the school routine for recreation and physical reinvigoration, for the school year is twelve months long. The Professor of Mechanical Engineering has expressed himself as thinking that he will not be justified in allowing students who have had a hard year's school work to cap that by more than a month of hard work in the shops, if on top of that is a laborious memoir, with the school session re-opening by August 20th for that class.

GRADUATE DEPARTMENT.

QUARTERLY MEETINGS.—We give below the minutes of the last quarterly meeting of the Association, and would call the attention of the graduates particularly to the proposed establishment of a Western branch, and ask that they forward to the Secretary of the Association suggestions as to the advisability of such action.

The discussion as to the addition of a fifth year to the School of Mines course will, we think, prove interesting, and as a special committee has been appointed to consider this subject, graduates feeling interested in the matter are requested to give their views on such points as they may deem proper to Prof. J. S. Newberry, School of Mines, New York, Chairman of the Committee.

The next meeting of the Association to discuss the report of the committee and also the advisability of abolishing the annual reunion, will be held in April at the School of Mines, and a full attendance is earnestly requested.

The following is the programme of the last meeting, which we print for the benefit of those who possibly may not have received it through misdirection or for other reasons.

ASSOCIATION OF THE ALUMNI OF THE SCHOOL OF MINES, COLUMBIA COLLEGE.

NEW YORK, Feb. 1, 1884.

DEAR SIR:

The second quarterly meeting of the Association for the year 1883–84 will be held in Hamilton Hall, Columbia College, on Tuesday, February 19, 1884, promptly at 8 P.M.

The proceedings of special interest will be as follows:

I.—A paper by A. W. Hale, E.M., of the Class of 1867.

II.—Discussion on proposed Amendments to the Constitution:

1.—As to the establishment of a Western Branch of the Association.

2.—As to the abolition of the Annual Reunion and Dinner, and the substitution of a Special Quarterly Meeting at the College.

3.—As to the Re-election of the Board of Managers.

—Discussion on the advisability of adding a Fifth Year to the School of Mines Courses.

An informal collation will be served at about ten o'clock, for which the usual charge of $1 *per capita* will be made.

If you expect to be present, please notify the Committee before February 18th.

Yours truly,

J. K. REES,
P. DE P. RICKETTS,
ALFRED L. BEEBE,
Standing Committee on Quarterly Meetings.

The meeting outlined in the foregoing notice was held in Hamilton Hall, Columbia College, on Tuesday, February 19, 1884, at 8.30 P.M.

Present, about sixty members of the Association, the first Vice-President, Mr. Wm. A. Hooker, in the chair.

The minutes of the last meeting were read and approved.

The Treasurer then presented an informal report as to the payments which had been made into the treasury, and on account of the QUARTERLY, by the different classes graduated from the School. He stated the net balance in the treasury to date to be $375.

On motion his report was accepted.

The Secretary made an informal report as to the last annual reunion of the Association, and read extracts from the minutes of the same.

Prof. Rees, the chairman of the QUARTERLY Board, reported informally, and stated that 276 subscriptions to the QUARTERLY had been received—80 from undergraduates, 10 from outsiders, and the remainder from graduates of the school.

He stated that the exchanges were numerous and increasing, also that an arrangement had been made to publish reprints from the QUARTERLY in book form, the first of which would shortly appear. Subject, "The Present Aspect of Ore Dressing in Europe." These reprints are to be published by Messrs. John Wiley & Sons, who are to pay a percentage to the QUARTERLY Board. Prof. Rees also urged the advisability of a copyright for the QUARTERLY, and stated that the second reprint, soon to follow the first, would be on the subject of "Ore Deposits," by Prof. Newberry.

On motion the report was accepted.

The committee appointed at the last quarterly meeting to draw up resolutions commemorative of Frank Stuart Helleberg and Henry Albert Hodges, reported through the Chairman, Mr J. B. Mackintosh, that said resolutions had been drawn up and published in the QUARTERLY. Copies had also been forwarded to families of the deceased.

On motion the report was accepted and the committee discharged.

The committee appointed at the last quarterly meeting to communicate with graduates, and to draw up resolutions indicative of the feeling of the Association in regard to the proposed reorganization and change of name of the School, reported, through Mr. W. P. Butler, that 169 members of the Association had voted against any change of name, and that the resolutions against such change had been disapproved of by one member, the balance of the graduates having made no return.

On motion the report of the committee was accepted, subject to correction by the chairman, Dr. Goldschmidt, and the Secretary was instructed to place the same on file.

Mr. A. W. Hale, of the class of 1867, after some preliminary remarks, read a paper upon "Culverts and Embankments," illustrating the same by drawings and formulæ.

Moved and seconded that a vote of thanks be tendered Mr. Hale for his valuable and interesting paper, and that the same be published in the QUARTERLY. Carried.

The chairman of the Standing Committee on Constitution and By-Laws appointed at the special meeting of the Board of Managers held Jan. 23d, 1884, then presented the following resolutions for discussion :

Resolved, 1st, That on the *first of January*, 1885, a Western Branch of the Alumni Association be established.

2d, That the head-quarters of such Western branch shall be located as nearly as practicable at the centre of the western mining field.

3d, That such location shall be determined by the vote of the members of the Association.

4th, That the *first* and *third Vice-Presidents* and the *Assistant-Secretary* of the Association shall be respectively, *Ex-Officio President, Vice-President* and *Secretary* of the Western branch, and shall constitute an *Executive Committee* of the Board of Managers for said Western branch.

5th, That the Constitution and By-Laws, and Act of Incorporation, if necessary, be so amended as to provide for the establishment of said Western branch:

Mr. Hale stated that there was a tendency to systematize mining, smelting, etc. in the West, and that there was an opportunity there for the Alumni Association to aid in the work, and also help its individual members.

Denver was suggested by Messrs. Lawrence, Reed and others as a centre or head-quarters for such Western branch.

Mr. Beebe stated that he thought the location should be determined by members in the West, who were directly interested in the matter, and moved that the resolution should be amended, so that the location should be determined by a vote of the members who are permanently located west of the Mississippi. After some discussion, the chair decided that no amendment could be made at this meeting, as the committee was appointed by the Board of Managers, and could report only to that body.

Moved and seconded that the report of the committee be accepted, and that it be suggested to the committee that it communicate through the medium of the QUARTERLY with the graduates in the West, and ask the latter to individually advise the committee as to the proper place to establish such a Western branch, what its scope should be, etc.

A discussion on the advisability of adding a fifth year to the School of Mines course was then called for.

Prof. Munroe stated that on looking over the old catalogues of the School of Mines, he found that for the graduating class the lectures given occupied only from one to two hours a day, the remainder of the time being given to laboratory and project work.

He stated that the outside work required was more severe than formerly, and that the lectures had been increased in number, so that the students on some days of the week had as many as five consecutive hours of lectures. The most obvious means of relief was to add a fifth year to the course. The drawback to this suggestion would be the effect upon the men proposing to enter the School of Mines. Could not other means of relief be found? As it is now, the mining engineer is a metallurgist as well as mining engineer, while some branches of metallurgy alone constituted separate professions, such as the Metallurgy of Iron, manufacture of Bessemer Steel, the Smelting of Copper, etc.

In mining engineering, Prof. Munroe stated that there were at least three distinct and separate lines of work, each in itself sufficient for the professional work of a lifetime, such as the mining and preparation of coal, the mining of metalliferous veins, the work of the expert. Each of these required a separate and special experience in order to be carried out successfully. The question is, are we not making too much out of our graduates?

Mr. Ferrer followed Mr. Munroe, suggesting that if a fifth year were added to the course the effect would be that students would go to

other schools and colleges, where they would get their degrees in four years.

Prof. Rees stated that Prof. Potter of Washington University, St. Louis, had found that it was impossible to give the young men in that University the advantages of a full professional education, without increasing the requirements for admission, or adding a year to the course. With him the fifth-year plan had worked well; he required attendance two or three times a week in the way of conferences. The student visits various works and gets points for the several projects in the interim.

Moved and seconded that a committee of five be appointed to consider the question, and prepare a report to be presented at the next meeting of the Association, the committee to be appointed by the chair. Carried. The chair appointed Prof. Newberry, Dr. Ledoux, Prof. Munroe, Dr. Love and Mr. Hale.

Moved and seconded, that the other subjects for special discussion, owing to the lateness of the hour, be left over until the next meeting, and that the meeting adjourn to partake of the collation provided. Carried. The social reunion was continued until about 11.30.

CHANGES OF ADDRESS.

Among these we note that of Mr. W. F. Staunton, from Tombstone, Arizona, to 62 William Street, New York City. We understand that Mr. Staunton, Mr. W. H. Cooper, Mr. W. F. Downs and Mr. A. J. Moses have formed a copartnership under the firm name of Cooper & Staunton, for the purpose of carrying on engineering and professional work. We wish the new firm every success.

The following is a list of all the changes in the addresses of the graduates received to date. The Secretary earnestly requests that the members of the Association keep him posted as to further changes, and begs leave to draw their attention to the fact that after this year only the addresses of those who take an active interest in the Association will be preserved and published:

1868.—Wm. Pistor, E.M., succeeds Hamilton & Pistor, Architects, 35 Broad Street, New York City.

1869.—Fredk. Bruckman, E.M., 309 West Eighth Street, Leadville Col.

1874.—F. H. Williams, E.M., St. Louis Ore and Steel Works, South St. Louis, Mo.

1875.—Arthur Macy, Ph.B., C.E., Silver King Mining Co., Silver King, Pinal Co., Arizona.

A. F. Schneider, E.M., C.E., Box 211, Socorro, New Mexico.

1876.—Geo. Cyrus Tilden, C.E., Hildebrand & Tilden, Assayers and Chemists, 247½ Seventeenth Street, Denver, Col.

1879.—Thos. H. Leggett, E.M., Flushing, Queens Co., L. I.

Charles Wells Marsh, Ph.B., care of Lazell, Marsh & Gardiner, 10 Gold Street, New York City.

Knight Neftel, C.E., Ph.D., Yale & Towne Co., Stamford, Conn.

T. S. Mathis, E.M., Telluride, San Miguel Co., Colorado.

Robert Dunn Rhodes, E.M., Box 211, Socorro, New Mexico.

1882.—Clarence Q. Payne, E.M., Stamford, Conn.

W. F. Staunton, E.M., Cooper & Staunton, 62 William Street, New York City.

C. L. Fitch, E.M., 108 West Forty-second Street, New York City.

1883.—Randolph Adams, E.M., N. Y., L. E. & W. R'y., Susquehanna, Pa.

J. P. Channing, E.M., Eureka Iron Foundry, Houghton, Mich.

THE FOLLOWING EXTRACTS FROM THE REPORT OF THE TRUSTEES OF COLUMBIA COLLEGE to the Regents of the University of the State of New York, adopted December 3, 1883, have been printed in pamphlet form by order of the Trustees, for distribution among the Alumni and friends of the College :

STUDENTS.—The following tables show the number and classification of the students in the several departments during the year ending September 30, 1883 :

DEPARTMENT OF ARTS.

Freshman Class	90	
Sophomore "	74	
Junior "	62	
Senior "	60	
Resident graduates	4	
	—	290

SCHOOL OF MINES.

Class of First Year	80	
" Second "	78	
" Third "	73	
" Fourth "	35	
	—	266

SCHOOL OF LAW.

Junior Class	188	
Senior "	212	
	—	400

SCHOOL OF POLITICAL SCIENCE.

Class of First Year	20	
" Second "	6	
" Third "	4	
	—	30
		986

GROUNDS AND BUILDINGS.—The following statement contains a true account of the dimensions and character of the grounds, and of the dimensions, character and uses of the several buildings belonging to or used by the institution during said year :

1st. The grounds consist of the block of land bounded by Madison and Fourth Avenues, Forty-ninth and Fiftieth Streets, being in length on Forty-ninth and Fiftieth Streets four hundred feet, and in width on each of the said avenues two hundred feet.

Estimated value $400,000

2d. The buildings are severally as follows : A building on Madison Avenue, four stories in height, two hundred feet in length, and fifty-four feet in width, used for the Undergraduate Department, the School of Political Science, and the Graduate Department; the old main building on Fiftieth Street, four stories in height,

100 feet by 60 feet, with two wings, each 30 feet by 30 feet, used for the School of Mines and the Undergraduate Department; the Chapel and the upper room formerly used for the Library, but now vacated, both contained in a building 85 feet by 35 feet; the School of Mines on Fiftieth Street, three stories high, 130 feet by 45 feet; an adjoining building on Fourth Avenue, not quite finished, five stories high above the basement, about 120 feet by 46 feet, intended for the collections and for instruction in the School of Mines; a building on Fourth Avenue next adjoining the last, five stories high, 35 feet by 45 feet, for instruction in the School of Mines; also the Library building, of irregular shape, 120 feet long on Forty-ninth Street, and 106 feet in greatest width, occupied by the Library and Law School, together with the Observatory.

Estimate value brought forward	$400,000
Estimated value, including furniture	1,015,000
Value of grounds and buildings	$1,415,000

EDUCATIONAL COLLECTIONS.—The several educational collections belonging to and used by the Institution during said year are enumerated in the following statement under the several heads of Library, and Apparatus and Collections:

1. LIBRARY.

Number of volumes added during the year, 1,212; present number of volumes, 50,320.

Estimated value	$170,672 56

2. APPARATUS AND COLLECTIONS.

Estimated value	209,284 46
Herbarium	26,300 00
	$406,257 02

COLLEGE PROPERTY.—The subjoined statement truly represents the property of the Institution at the end of said year under the several heads enumerated:

Grounds and Buildings	$1,415,000 00
Educational Collections	406,257 02
Amount invested in Bonds and Mortgages	377,323 91

In this amount is included a mortgage on land near Carmansville, upon which is now due $356,661.54, without interest, which mortgage represents an investment made in that form with a view of eventually taking the title and using the land as a site for the College, if it should thereafter appear to be expedient.

Amount invested in real estate other than College grounds and buildings, consisting of lands in the City of New York, leased by long leases, yielding a net revenue of 5 per cent. on a capital of	4,257,546 80
A cash balance of	6,502 74
Deposited in the New York Life Insurance and Trust Co.	3,536 56
Advances to the Dean of the School of Mines	1,000 00
Advances to the Superintendent of the heating apparatus	400 00
Advances to the Librarian	700 00
Total	$6,468,267 03
Debt at the end of the year	273,240 00
Net property	$6,195,027 03

This property is subject to the endowment of a professorship by a legacy of $20,000, and to the endowment of several free scholarships and of a prize.

REVENUE AND EXPENDITURES.—The revenue and expenditures of the Institution during said year have been as given in the following statement:

1. REVENUE.	
Fees for tuition collected	$115,916 40
Other receipts from students	10,753 71
Income from invested funds	2,927 41
Rents	211,185 51
Arrears of rent	1,296 00
Interest on rents	146 01
From all other sources	176 69
Total	$342,401 73
2. EXPENDITURES.	
Salaries paid for instruction, including compensation of officers and servants	$196,840 76
Salaries for general administration	19,708 67
Prizes, fellowships, scholarships, etc	3,960 00
Improvements and repairs of buildings and grounds	26,440 63
Annuities	3,250 00
Fuel and other incidental expenses	72,870 98
Interest on debt	5,080 96
Payments on account of new buildings	206,834 46
Furniture for the same	19,932 53
For all other purposes, that is to say, the net charges on the property near Carmansville	772 62
Total	$555,691 61

THE OTHER SUBJECTS referred to in the Report from which the foregoing extracts are taken, are as follows: Calendar, Board of Trustees, Faculty, Graduation, Requirements for Admission and Courses of Study. Full information on all these matters is given in the Register and Handbook of Information annually published by the College.

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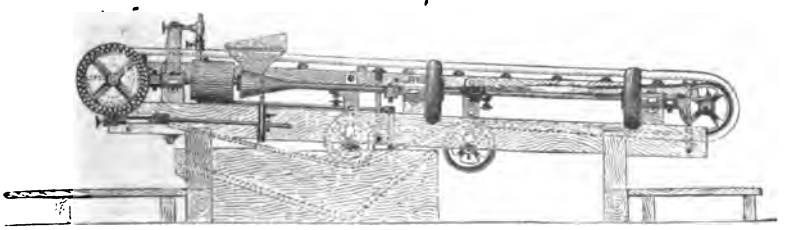

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SCHOOL OF MINES QUARTERLY.

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THE METROLOGICAL SYSTEM OF THE GREAT PYRAMID.

BY PRESIDENT F. A. P. BARNARD, S.T.D., LL.D.

Read before the American Metrological Society, Dec. 27, 1883.

(*Concluded from page* 217.)

Of the Pyramid coffer as a standard of capacity measures, enough has perhaps been said; but there remains one observation to be made in regard to it too important to be omitted, the more especially as it seems not to have occurred hitherto to any writer on the subject on either side of the question. It is this: If this object was really intended to be a standard of capacity measures, it evinces, on the part of its designers, an astounding ignorance or a most culpable disregard of the principles which ought to govern such a construction. The use of a standard measure of any kind is implied in its name. It is to serve as a means of adjusting, by comparison, measures of similar character to be employed by the people in the daily transactions of business. An absolutely essential requisite of such a standard, therefore, is that it shall be of such moderate dimensions and inconsiderable weight as in the highest degree to facilitate manipulation. The same properties are equally necessary in order that it may easily lend itself to the processes necessary to test, from time to time, its own accuracy.

Among all enlightened nations, at the present time, capacity

standards are tested by ascertaining experimentally the weight of distilled water they will hold when completely filled, the quantity being determined by weighing at a given temperature and under a given atmospheric pressure, with counterpoises also of given specific gravity—this last condition being required in order that allowance may be made for the weight of the air which these counterpoises displace. Moreover, in order to secure the accurate filling of the vessel, a peculiar artifice is resorted to. The unaided eye cannot be depended on to ascertain this point; for, on the one hand, in consequence of the property called capillarity, the fluid creeps up the walls of the vessel making it higher at the edges than over the general surface, so that the vessel may seem full before it is really so; and, on the other, in consequence of the property of viscosity, the vessel may be made heaping full without running over. In order to avoid either of these errors, the expedient is adopted of grinding the upper edge or rim of the vessel to a true plane surface and preparing for it a plate-glass cover, also ground to a true plane. Then, when the vessel is apparently full, the cover is placed over it. If it is heaping full the excess of liquid will be expelled, and the volume of water remaining will represent the exact capacity of the measure. But if the filling had not been complete, the deficiency will appear in the form of a bubble of greater or less magnitude, which, by artifices familiar to experts, may be brought to the middle of the glass cover, where there is a small orifice through which the confined air escapes, and through which, also, the deficiency of liquid may be supplied. This vessel, thus filled, after being carefully dried on the exterior, is placed in the balance and weighed. The difference between the weight thus found and the previously ascertained weight of the empty vessel and cover will be the weight of the contained water.

Now, in order that a process of this kind may be conveniently carried on, it is important, indeed indispensable, that the vessel shall be as light as is consistent with the preservation of its figure, and that it shall be easily portable as well when full as when empty; so that a standard-measure of capacity of such ponderosity as to be beyond the strength of a man to lift either full or empty, is nothing less than a preposterous absurdity. Tried by this test the pyramid coffer was either never designed to be a standard-measure, or it was the work of stupid dolts who had not the slightest idea of what a standard

should be. The measurements of Prof. Smyth inform us that, in round numbers, this vessel measures externally, in length, seven feet six inches; in breadth, three feet three inches; and in height, three feet six inches. The same authority tells us that the interior capacity is equal to just one-half the entire solidity of the block whose external dimensions are above given; and as the specific gravity of Egyptian granite is 2.654, we are able to compute that its weight, when empty, is equal to 6,855 pounds avoirdupois, and, when full, to 9,434 pounds. That is to say, this prototype capacity-measure for all the world weighs nearly three and a half tons, and the volume of water required to fill it weighs one and a quarter tons—the whole weighing together four and three-quarters, that is to say nearly five, tons.

After this it is hardly worth while to remark on the folly of shutting up a measure intended for a standard in the heart of a mountain of rock, so as to be accessible only through a series of absolutely dark passages four hundred feet long, most of which a man can only traverse by crouching or crawling, and which were, moreover, so effectually plugged up by the builders less than one hundred feet from the entrance, that, but for the violence of a Mussulman caliph, the world would never even have known of their existence. Still less necessary is it to remark on the isolation of the object from all sources of water, or the absence of means of distillation, or of ascertaining weights, if water were present.

We may therefore very safely conclude that this object is by no means what Prof. Smyth calls it, "a deceiving blind," that is to say an apparent sarcophagus only, and a real measure of capacity. It is, on the contrary, plainly what it professes to be —an honest, outspoken, truth-telling sarcophagus, and nothing else.

The pretensions of the coffer as a measure of capacity having been thus so thoroughly disposed of, it is hardly necessary to say anything of it further as a standard of weight or of length. But there is something so defiant of common sense in the manner in which the theorists have looked at this side of the subject, that it can hardly be passed wholly in silence. The weight of water which the coffer will hold is the Pyramid ton, which is the theoretic Pyramidistic unit of weight. But inasmuch as, for practical purposes, a liquid measure of weight is an absurdity, the theorists find an equivalent solid by dividing the

capacity of the coffer by 5.7, the assumed mean specific gravity of the earth. The result is a solid Pyramid ton of the bulk of 12,500 cubic inches of an imaginary material having a density equal to the earth's mean density. The principle of *fiveness* then seems to demand that five cubic inches of this substance, being the twenty-five hundredth part of a Pyramid ton, should stand for the practical unit in the petty transactions of every-day life, viz., the Pyramid pound, a weight undoubtedly convenient, since it exceeds the pound avoirdupois only by an amount a little less than half an ounce. But the material of which this type-weight is to be formed is so unfortunately chosen that there is no substance anywhere to be found upon the face of the earth, nor in its crust so far as it has been penetrated, which is fit for the purpose. That which comes nearest to the density required is metallic arsenic, of which the specific gravity varies from 5.62 to 5.96; but this substance, to say nothing of its noxious properties, is without tenacity or malleability, and is nearly as brittle as glass. Nor could such a material have been prepared artificially by a combination or alloy of metals, for the specific gravity of every metal known before the nineteenth century (*except arsenic*, as above mentioned) is higher than 7, and that of many much higher.

Thus in the metrological system of the Pyramid, the prototype standard of weight is a pure creation of the fancy, of which the practical realization is impossible.

Considered as a standard of length, the coffer is more illusive still. If it had been designed to furnish a standard of this sort, common sense would seem to dictate that, in some one of its dimensions, indeed, if not in all, it should directly illustrate the value of this standard. But neither in its length, its breadth, or its depth, whether measured externally or internally, do we find the sacred cubit, or a multiple or simple fraction of that measure; more than that, we do not even find, in any one of these dimensions, a round whole number of Pyramid inches. But the genius of the Pyramid theorists rises above these petty difficulties. The standard of length is in the coffer notwithstanding; and this is the way in which it is evolved to light. The capacity of the coffer having been divided as above, by 5.7, the earth's mean density, it is revealed to us that the resulting 12,500 solid cubic inches, the Pyramid ton, have exactly the volume of one-tenth of the cube of a double sacred cubit. We have only, therefore, to multiply the number just mentioned

by ten, and then a simple extraction of the cube root will furnish us the standard of length required.

Even, however, after we have successfully accomplished this arithmetical operation, we are a good way off from the material and tangible working standard through which only any system of metrology can be practically useful to the human race.

In now regarding this metrological theory of the coffer as a whole, one cannot fail to note how completely it is penetrated through and through with the stamp of a modern invention. It is ingenious, no doubt, but its very ingenuity condemns it; for it betrays the immense amount of labor and study it must have cost to build up a consistent, and in so many respects plausible, system out of materials so insignificant and meagre; but just in proportion as, under the hands of the enthusiastic inventors, the system grows in elaborateness and symmetry, in the same proportion the probability fades away that the builders of the Pyramid ever entertained the least conception of such a creation.

But if it is really necessary to suppose that the constructors of this wretched stone box imagined that they were making anything more important than a receptacle for the mouldering remains of a mortal man, it seems to me that the numbers connected with it suggest what Prof. Smyth would probably call "a much grander reference in science" than any scheme could be, however ingenious, for regulating the petty traffic of the wine-shop and the butter-market. I make this appear as follows: Prof. Smyth has pointed out (*Our Inheritance*, etc., p. 188) that 5,151.65 Pyramid inches is the length of the side of a square equal in area to a meridian vertical triangular section of the Pyramid, or to a circle having the height of the Pyramid as a diameter. Now the capacity which he prefers to give to the coffer is 71,250 cubic Pyramid inches; and this number, stated as a decimal, is the logarithm, in our common system (omitting the index), of 5,158.3. which, regarded as British inches, are equivalent to 5,153.1 Pyramid inches. The coincidence is very close, and the slight discrepancy will be seen to be of no significance when we take into account the following considerations:

1. The capacity 71,250 has been adopted by Prof. Smyth, not because it is the exact result of any computation, but because it corresponds conveniently to his theory of the *fiveness*

of the Pyramid. He has evidently no confidence in the exactness of the results obtained by immediate measurement; and his distrust is justified, since the surfaces measured are not plane but more or less concave, and the fiducial edges have for the most part disappeared. He therefore assumes a value for capacity which is "somewhere among" (a favorite method of his) those actually obtained, though it corresponds to no one of them, nor even to their mean. His different values are derived from a theory, which seems to be exalted to the dignity of an article of faith, that the interior capacity of the coffer is, and was intended to be, exactly one-half the volume of the original block, which we see still unaltered in its outside dimensions. The three values of the capacity hence obtained are as follows:

1. From direct interior measurements.....71.317 cu. in.
2. From direct exterior measurements (one-half).....71,160 " "
3. From sum of bottom and sides directly measured.....71,266 " "

How little reliance can be placed on these measurements may be judged from the fact that the mean of the first and third of the foregoing results, which, on any theory, ought to be equal to the second, is 71,291.5 cubic inches—that is to say, 131.5 cubic inches in excess. The mean of all the three values is 71,247.7 cubic inches, and this is so satisfactory to Prof. Smyth that he expresses himself in regard to it thus complacently: "Here then we have a vessel whose cubic contents are not only something excessively near to 71,250 cubic Pyramid inches, but it was pretty evidently intended to be both of that quantity within some minute fraction, and to carry a check and witness thereto down through all fair accidents, through all ages to distant time." (*Our Inheritance*, etc., p. 145.) If, therefore, 71,250 is not the exact logarithm of the side of the square above described, it is because, in the first place, it is not the exact value of the coffer's capacity.

2. The area of the meridian triangular section of the Pyramid depends materially upon the dimensions assumed for the base. Prof. Smyth has adopted 9,140 British inches, equal to 9,131 Pyramid inches, for his base measure; not because any investigator has ever found that measure, but because the number is necessary to his theory of the sacred cubit and the days of the tropical year. But, as the measurements given by different authorities differ as widely as between the 9,110 British

inches of Mr. Inglis, and the 9,168 of Col. Howard Vyse, I trust that, since Prof. Smyth has taken the liberty to adopt a dimension favorable to his theory, I may be allowed a similar liberty in regard to mine. If, then, the side of the base be assumed to be 9,142.8 Pyramid inches, as it suits me to assume it, the side of the square equal in area to the triangular meridian section will be 5,158.3 Pyramid inches, and in this case 71,250 will be its true logarithm.

3. But, inasmuch as we have seen that 71,250 cubic inches is not the capacity of the coffer, but only the capacity which Prof. Smyth guesses the coffer ought to have, and was probably meant to have; and as we have further seen that the real purpose of the constructor was, apparently, to make it of the capacity of a double royal cubit cubed, while the cube of the double cubit of Karnak a little exceeds the mean of Prof. Smyth's results; since, moreover, it has appeared that the royal cubit in actual use was sometimes a little longer and sometimes a little shorter, so that the double cubit used in the entrance passage seems, according to Prof. Smyth's measurements, to have varied from 41.46 to 41.63, while in the King's Chamber it was 41.25 or 41.26, we may be justified in assuming the double cubit employed by the constructors of the coffer to have been a trifle shorter than the Karnak rule, which latter, as we have seen, is 41.472. If we put it at 41.454, we shall obtain a theoretic capacity of 71,236 cubic British inches; which number taken decimally is the logarithm of 5,156.7 British inches, equivalent to 5,151.55 Pyramid inches, differing but a tenth of an inch from the side of the square in Prof. Smyth's calculation.

It is very clear to me, therefore, that, while the builders of the Pyramid designed to furnish, in the general external form of the structure, a visible and tangible solution of the knottiest problem of plane geometry, the quadrature of the circle, it was their purpose, in the construction of the coffer, to display their familiarity with the powerful algorithm of which we mistakenly ascribe the invention to the seventeenth century, and which we associate with the illustrious name of Napier, or in its ordinary form, with the less illustrious one of Briggs.

We have now passed in review all the really important points of the Pyramid faith. If these cannot be sustained, what remain are not worth the breath their discussion would cost. In fact, if the doctrine of the divine authority of the cof-

fer alone breaks down, the whole theory tumbles together. We will nevertheless consider briefly the topics of secondary importance not yet disposed of.

The first of these is the latitude of the Pyramid. It is regarded by the theorists as a significant fact that this structure was, or was intended to be, placed upon the thirtieth parallel of north latitude. No evidence is presented of the probability of this purpose, in the minds of the builders, except that the monument happens to be pretty near to that parallel; and that parallel has certain relations to the geography and meteorology of the globe which have been discoveries of the later centuries, and which we are justified in pronouncing with great positiveness to have been, so far as they are true, wholly unknown to the human race until within a comparatively quite recent period. These are 1st, The thirtieth parallel divides into two exactly equal portions the surface of the hemisphere, land and water included, between the equator and the pole. 2nd, The thirtieth parallel enjoys a mean climatic temperature which is that of the entire habitable world. 3d, "Taking the distribution of land and sea in parallels of latitude, there is more land surface in the Great Pyramid's parallel of latitude than in any other." (*Our Inheritance*, etc., page 67.)

In regard to the first of these points it may be remarked that no evidence exists to show that the globular figure of the earth had been recognized by the Egyptians of the time of Khufu, or that, if it had been, that they had any acquaintance with the geometry of the sphere. If to this it should be replied that the emplacement of the monument was not intended to be significant to the men of that time, but to us, we may rejoin that we have no need of it, since all that it could tell us had been known to Western Europe some centuries before the sagacity of Prof. Smyth succeeded in detecting and making clear to us what were the secret purposes of the Egyptian mind six thousand years ago.

As to the second point, it is simply impossible that the slightest conception should have been entertained of such a science as comparative climatology in the age of pyramid construction, or that any differences of climate had ever been observed at all, except as they might affect personal comfort. That the pyramid builders should have placed their structure on the thirtieth parallel because that is the latitude of the earth's mean temperature is simply an impossibility, because

even if that were true, they knew nothing about temperatures, still less about mean temperature even of a particular locality, and a great deal less still about the mean temperature of the planet. The ancient Egyptians knew nothing of countries outside their own, except of those with which they were brought into contact by wars, and these were limited to Lybia, Ethiopia, Arabia and Syria, all of which were climatically much of the same character.

But it is not correct to say that the mean temperature of latitude 30° represents the mean temperature of the entire earth. If this should accidentally be true in one longitude it would probably not be so in any other; for parallels of latitude are nowhere isothermal lines: and the isotherm of 58° F., which, according to Prof. Dove, represents the mean temperature of the earth, is near latitude 40° in the Atlantic Ocean, and down as low as 30° on the coast of China; passing through Constantinople about eight hundred miles north of Cairo. Upon Guyot's meteorological maps, the isotherm passing through lower Egypt, near Cairo, is that of 72° F. Thus, if it was intended to mark by the Pyramid the region of the earth's mean temperature, its actual location was a blunder.

But, in point of fact, the Pyramid was not erected on the thirtieth parallel. It is actually more than a mile too far south. Two explanations have been given of this error: they should perhaps be called apologies for it. The first is that, as the latitude was probably determined by observation of Alpha Draconis (the pole star at that time), and as, in consequence of the refraction of the atmosphere, of which the builders knew nothing, the apparent altitude of the star was greater than the real altitude, the latitude observed was in excess of its real value, and hence the site was thrown too far south. To which we may reply, first, that the explanation is inadequate, since the correction for refraction, though it diminishes the error, fails to eliminate it; and secondly, that a divine illumination which had revealed to these men such difficult truths as the exact length of the earth's axis, and the correct distance of the earth from the sun, could hardly have failed them in so simple a matter as a question of terrestrial latitude.

The second of the apologies above referred to is equally unsatisfactory. It is that the pyramid was placed as far north as the extent of the Gizeh plateau would allow, and was even crowded up to the extreme northern brow of the declivity

but that this fell more than a mile short of the thirtieth parallel. This is a very lame explanation. If, as we are taught to believe, it was among the conditions prescribed by the Supreme Being, that the monument should be built on the thirtieth parallel of latitude, then either the Gizeh hill would have been under that parallel, or some other site would have been sought in which the condition might be fulfilled. The divine purpose could never have been baffled.

The probability, however, is that the builders never thought of the latitude at all. The pyramid, wherever built, must have been on or near some parallel. It might as well have been the parallel of thirty as any other. The Gizeh hill was chosen because it was a good place to build on. That is all the explanation of the emplacement needed.

The particular longitude of the pyramid's site seems to be regarded by the true believers as no less important than its latitude. If the structure were to be merely a metrological standard, one fails to see why it could not subserve its purpose as well in one country as in another. There seems, however, to have been an overruling necessity that it should be built in Egypt and nowhere else; and hence its builders were impelled ("led by the Spirit of God," Mr. Taylor says) to leave their own country in the plain of Shinar, and "to undertake the fulfillment of the great design" in that foreign and to them hostile land. For that it was hostile, both Mr. Taylor and Prof. Smyth concur in testifying, when they seek to identify its rulers with the Shepherd Kings of the middle dynasties, concerning whom history is so nearly silent, but who are mentioned in one of the fragments of Manetho, still extant, as follows: "We had formerly a king whose name was Timaos. In his time it came to pass, I know not how, that God was displeased with us; and there came up from the East, in a strange manner, men of an ignoble race, who had the confidence to invade our country, and easily subdued it by their power without a battle." These were the Shepherd Kings, who, having mastered the country, shut up the temples, and, as tradition asserted in the time of Herodotus, inflicted such cruelties upon the inhabitants that their memories were held in after ages in detestation, and people refused even to speak their names. Mr. Taylor, however, shrewdly suspected that these rulers were hated, not so much because they were bad, as because they were good—that is to say, pious—while the people who

hated them were bad—that is to say, idolators, indignant at the closing of their temples. Along with them came certainly, as Mr. Taylor believes, the thirteen sons of Joktan, of whom the youngest was Jobab or Job, whom the same writer endeavors to identify with the afflicted man of Uz. After describing at some length the character of this people, Mr. Taylor goes on to say regarding them: "There could have been no motive sufficient to allure such a people as this to the banks of the Nile, according to the views usually taken of men's conduct. To build sepulchres of so vast a size in which no human being was ever laid—to build them for their own sepulchres, and then to leave them as soon as they were completed, in order to go to some other country for the rest of their lives, and there to be buried in obscure graves—is too absurd a supposition to be entertained concerning any rational creatures; and that these men were wise above most others is shown by their works. To build storehouses for corn of so vast a bulk without leaving in them any chambers capable of holding corn, or accessible to persons bringing it, even if the chambers were large enough, is to attribute to the founders of the pyramids a degree of folly of which no people in the world were ever capable. For one purpose alone does it seem reasonable to conclude that any men should have undertaken so prodigious a labor, without looking for the slightest advantage to themselves; and it is that purpose for which we have seen so much evidence adduced as to force us to conclude that it must have been the end for which the pyramids were formed, viz., that they might serve as a record and memorial to the end of time, of the measure of the earth; and secondly, form a standard of measures of length, capacity and weight to which all nations might appeal as to a common authority, in their dealings with each other. But to attribute to the founders so grand and liberal a design, is to affirm that they were the greatest philosophers and the greatest benefactors the world ever knew."

It would be difficult to find, throughout the whole range of English literature, a proposition more ludicrously absurd than that which is embodied in the last sentence of the foregoing paragraph. The grandeur and liberality of the design manifested in the creation of the pyramid, consisted in the lavish prodigality with which human labor and the wealth wrung from the hard hands of a suffering people, were squandered in

heaping up a monstrous pile of stone, from which its builders "looked for not the slightest advantage to themselves," and which, it may be added, could not possibly be of the slightest advantage to anybody else. Instead of being styled "the greatest philosophers," they would rather deserve to be stamped, unless some better interpretation of their work shall be discovered than has yet appeared, as the greatest dunces of antiquity. And when pæans are raised to them as "benefactors" of mankind, we may reasonably inquire whom they have benefited. Not certainly the generation whose miserable lives were crushed out of them in the intolerable toil exacted for the erection of these stupid structures. Not those who successively lived and died during the thousands of years in which the mysterious chambers of these monuments remained sealed against all intrusion from the living world. Not Al Mamoun, who with infinite labor penetrated into these same mysterious chambers, to find there, as his only reward, a huge and meaningless stone box, with or without a lid. Not ourselves, among whom these titanic structures have served no better purpose than to provoke unprofitable speculations and to stimulate brains which might be better employed, in weaving fantastic theories with which to clothe very ordinary objects with mystery. Not anybody has been benefited by them, from the beginning down to this day; nor, it may be added, could anybody have been benefited by them, if every dogma of the Pyramid religion had been literally true.

For it would be difficult to persuade a sane man that there is anything more intrinsically salutary to mankind in one particular measure or length, or of weight, or of capacity, than in any other. The properties which make any metrological system beneficial, are not the particular values of its units, but the relations of its denominations, uniformity in its practical applications, and facility of verification of its standards. The Pyramid system has never been in use and never will be; so there is nothing to be said upon either of the first two points. And as to the facility of verification in this system, it will probably be admitted, after what has been said above in regard to the coffer, that the possibility does not exist.

To return to the Shepherd Kings: as it is perfectly established by modern researches that the intruders so called belonged to the fifteenth, sixteenth and seventeenth dynasties,

while the Pyramids were built by the rulers of the fourth, Prof. Smyth finds himself constrained to give them up. But he says: "That these *later* or 15th., 16th., and 17th., dynasty Shepherds did not build the Jeezeh, or indeed any of the Egyptian, Pyramids, does not by itself overthrow the whole theory or possibility of there having been an *earlier*, or quite distinct, Shepherd invasion, or temporary rule of Hyksos in lower Egypt, and perhaps even during the fourth or chief Pyramid building dynasty; for pastoral tribes existed in the East from the earliest times, and were much endued with tendencies to western emigration." (*Our Inheritance*, etc., p. 421.) While it surprises us a little to find Prof. Smyth here attributing the migration of the Pyramid builders to an unintelligent instinct, or native tendency, while Mr. Taylor tells us that they were "led by the spirit of God," we know, nevertheless so well what are the "tendencies" of the Professor, that, after this outgiving, we feel quite confident he will presently find what he wants. We are not disappointed; he quotes a little further on (p. 430), the following from Herodotus, which, in his view, clears up the whole difficulty: "They (the Egyptians) commonly call the Pyramids after Philition or Philitis, a shepherd who at that time fed his flocks about the place." This shepherd Philition becomes presently Prince Philitis; and then, after reciting the words in which Manetho, speaking of the Hyksos of the middle dynasties, makes them return to the East and build there a great city, our author proceeds to say, with what strikes us as a singularly cool perversion of history, *we have here as much as testifies to the earlier and truer Shepherd Prince Philitis* (the italics are ours), after having long controlled King Shofo during the very time that the Great Pyramid was building—to that Prince Philitis, I say, the leaving the country with a high hand, or by special agreement, "with all his people and flocks—proceeding to Judea, and building there a city which he called Jerusalem." The name Jerusalem awakens a new association in the impressible mind of our Professor. He is reminded of "Melchizedek, further called king of Salem, which some consider to have been Jerusalem." He does not, in so many words, assert that Prince Philitis *was* Melchizedek; but he says that "he must have been, as to age, standing, country, and even title, very much such an one as that grandly mysterious character." And though he remarks that "the Bible does not indeed directly mention Melchizedek's

ever having been sent into Egypt on any special mission (the Bible in fact names Melchizedek historically only in one single passage)—the grandest of missions, if there to erect or procure the erection of a prophetical monument which was only to be understood in the latter days of the world; but was destined to prove the inspiration origin, and Messiamic character of its design to both religious and irreligious," yet we can see that he entertains no doubt either that Prince Philitis was in effect the builder of the Pyramid, or that Melchizedek was Prince Philitis (*Our Inheritance*, etc., p. 433).

These Biblical discussions have led us a long way off from the question of the Pyramid's longitude with which we began. But the importance of this question of longitude must have been, in the minds of the Pyramid builders singularly great, since if we are to believe the disciples of the faith in our own day, it was sufficient to induce them to undertake a migration of nearly a thousand miles, to attempt and accomplish the conquest of all Lower Egypt, to hold the country for a long period of years, and then to abandon it and go to establish themselves finally in a third country which they must have wrested in like manner, as they had wrested Egypt, by violence, from its lawful possessors. The only palliation which can be suggested for these successive acts of robbery, is to be found in the consideration that the army of Prince Philitis or of King Melchizedek, being engaged in the fulfilment of a divine mission, had a right of appropriation over such lands as they fancied, which was superior to the natural and merely human right of property.

To return to the question of longitude, from which these Biblical discussions have carried us away farther than we intended; what is there, we may inquire, in the longitude of Gizeh, which should make it indispensably necessary that the Pyramid should be erected under that meridian, and no other? What is there about that meridian to call for the sacrifice of home and country on the part of a nation, or at least a very numerous tribe, for a migration in mass, and a painful march of a thousand miles, for armies, conquest, the subjugation of a peaceful country and the enslavement of its unoffending inhabitants, and for the expatriation of the conquerors for more than a century, in the accomplishment of a mission connected with it? Certainly there must have been some object to be attained, of incalculable importance, to

justify this subversion of the foundations of society, this great movement of the nations, with all the wide-spread suffering which must have inevitably attended it. There was such an object, as our friends of the Pyramid persuasion inform us—an object of transcendent importance—an object which, when they reveal it to us, makes us hold our breath in admiration, and lay our mouths in the dust in silent conviction—it was in order that "the most magnificent, disinterested and glorious work that was ever conceived and executed by mankind" might be erected under a meridian of which it may be said that "there is more earth and less sea in that meridian than in any other meridian all the world round." To an argument so overwhelming in its force as this, of course, not a word can be uttered in reply.

It is a pity, nevertheless, that the proposition here stated is true only in the limited sense in which, by the word *meridian*, we understand a geographical semi-circle extending from pole to pole. If, however, we are permitted to define this word to mean an entire great circle of the sphere passing through the poles, there are several meridians which pass over more of *terra firma* than that of Gizeh. This is true, for example, of the meridian 60° W.—120° E. of Greenwich; also of the meridian 80° W.—100° E.; and of the meridian of New York City, which is nearly that of 75° W.—105° E., which last apparently possesses in very truth the property claimed for that of Gizeh, of having under it "more earth and less sea than any meridian all the world round." It is, therefore, to be regretted that Melchizedek, who probably knew nothing of meridians, nor anything even of geography beyond the region lying between and including Chaldæa and the valley of the Nile, had not been inspired to continue his westward march until he had found the meridian which enjoys really the distinction which belongs to that of Gizeh only in a qualified sense; since in that case the discovery of America might have antedated Columbus by three or four thousand years, and we might have had the Great Pyramid in our own Central Park.

The next point of the Pyramid faith which we have to examine is that which relates to this monument as a standard of temperature. In natural caves, and in artificial excavations beneath the surface of the earth, the extremes of heat and cold become less divergent as we descend; and at a quite moderate

depth become merged in one common temperature, the temperature due to the locality, which remains invariable throughout the year. That such a constant temperature should prevail in the heart of so large a mass of masonry as the Great Pyramid, is not improbable; that it would do so in the chamber left unfinished by the builders deep down in the rock beneath the base, is almost certain. But that that fact or probability was known to the builders, or that it was among the considerations which induced the erection of the structure, is a great deal more than doubtful. It is as nearly certain as anything not absolutely demonstrated can be, that they knew nothing whatever about heat and cold beyond the fact that the extremes of either are painful to the sense. The art or science of thermometry originated in the seventeenth century. None of the nations of antiquity, however enlightened, neither the star-gazing Chaldæans, nor the cultured Greeks, nor even the world-subduing Romans, though they pushed their conquests equally among the snows of Dacia and northern Gaul, and over the burning sands of Lybia and Ethiopia, had any notion of it. It is hardly probable that the Egyptians of the thirty-seventh century before our era were more advanced than these. But if they were, where is the evidence of it? How is it that, among all the relics of Egyptian art, and Egyptian science, and Egyptian life, that have been gathered together at Boulak, there is no fragment or trace of a thermometric instrument; or that among all the thousands of papyri and mural inscriptions that have been deciphered since our century began, not one makes mention of temperatures or their measurement? And if the builders really intended that the temperature of the King's Chamber should be accepted by posterity as a representative and exemplification of what they believed to be the mean temperature of the planet, why did they not in some form or other say so? Why, moreover, if they intended this standard temperature to be a term of comparison, did they devise no means by which comparisons could be made? What possible advantage could it be to any one to know that the temperature of the interior of this mountain of rock is so and so, unless he can be able to say that the temperature of some other place is higher or lower? He must either carry the place into the pyramid, which is impossible, or contrive some means of carrying the temperature of the pyramid to the place, or that of the place to the pyramid.

No evidence, or trace of evidence, of the existence of such instrumentalities is to be found. Prof. Smyth, indeed, talks coolly and confidently enough about "the two hundred and fifty degrees of the Great Pyramid scale" (*Our Inheritance*, etc., p. 260), meaning 250° between the freezing and boiling points of water; quietly assuming that there was such a scale; for no other reason that appears, except that the interior temperature is, as he assumes, that of 68° F., which is one-fifth part of the distance on the scale from 32° F. freezing, to 212° F. boiling; and that to divide this total interval into 250 parts would be more convenient than the division of either Fahrenheit, Reaumur, or Celsius, besides affording a beautiful illustration of his theory of the *fiveness* of the Pyramid. Now if the Pyramid builders had really a thermometric scale of this sort, it is truly a mystery defying explanation, that they neglected to contrive some effectual method of transmitting a knowledge of it to posterity, since they could not have reasonably anticipated that there would arise, after the lapse of some six thousand years, a genius sufficiently gifted to read, with the single clew offered by the constant temperature of the King's Chamber, their entire thermometric system, and to vindicate for them the glory of its authorship.

Only, unfortunately, Prof. Dove, the highest modern authority in meteorology, says that the mean temperature of the earth is 58° F. instead of 68° F., and the mean annual temperature of the Nile Delta is 72° F., and not 68° F.; neither of which statements is in harmony with the Pyramidistic property of *fiveness*.

It remains only to consider for a moment the astronomical significancy of the Pyramid. Very grave importance has been attached to this, chiefly because of the light it is presumed to throw upon the date of the erection. Two facts are relied on to demonstrate the relations of this monument to astronomy. They are (1) its true orientation; and (2) the inclination of its passages. As to the first of these facts, it is indisputable. The bounding lines of the Pyramid are directed more truly to the cardinal points of the compass than those of any other known structure erected by man before the invention of telescopic sights. The meridian established by Tycho Brahe, at his famous observatory of Uranienborg, has been found by more recent examination to have had an azimuthal error exceeding fourteen minutes, while the error of Pyramid

orientation was determined by Prof. Smyth's repeated and careful observation to be less than five minutes (4′ 35″), or not one-third so great. This near approach to exactness, however would not necessarily imply large astronomical knowledge, or a high degree of astronomical science, on the part of the builders. The idea of laying down a true north and south line by observation of the extreme eastern and western elongations of any conspicuous star near the pole, might easily occur to even an ignorant man, although considerable skill would be required to carry out the idea in practice.

The question, however, will naturally arise, why should the builders desire to give to their work this true orientation? Not certainly in order that the pyramid might be used as an observatory; for, in its completed condition it offered but one outlook toward the heavens, and that only in a direction less than four degrees from the pole; while for any practically useful purpose in astronomy, after the question of orientation had been settled, there could be no more utterly unprofitable species of observation than that of a close circumpolar star. If there was really a purpose in this apparently very careful adjustment of the faces of the pyramid toward the cardinal points, it would be difficult to conjecture its motive, unless we adopt the very plausible suggestion of Mr. Proctor, that the Pyramid was an astrological monument, and that its peculiarities were determined by the horoscope of the monarch who caused it to be constructed.

An astronomical significancy has been ascribed to the inclined entrance passage of the Pyramid, for no better reason than that it looks out toward a point of the heavens not very far distant from the pole of diurnal rotation. It has been already remarked that no conceivable purpose of interest to astronomical science could be subserved by observation in this direction after the position of the meridian line had been fixed; and it is certain that no advantage of any kind was derived from it after the completion of the Pyramid; since its mouth was closely sealed, and remained for centuries undiscovered. If, therefore, the inclination of this passage was really determined by any serious motive, and was not a result of mere hazard or caprice, we seem to be driven to conclude that it was designed to answer only some temporary end which ceased to

an interest after the work was done. We can conceive of

ch end, unless it were the adjustment of the orientation

of the building. This, in the opinion of Mr. Proctor, is the true explanation both of the north and south and direction of the inclination of the entrance. He supposes that an approximate north and south line was first found by raising a somewhat lofty and pointed upright upon a level plane; and then, at the moment of meridian passage of a circumpolar star, setting up another shorter one behind it, so that the tops of the two might exactly range with the star. The line connecting the uprights would then be a north and south line, subject to such inaccuracy as might naturally result from uncertainty, in the absence of artificial timekeepers, of the true moment of meridian transit. A more correct determination could probably be made by observations of the star at the limits of its largest excursions to the east and the west, and dividing the angle between the two directions thus obtained. Mr. Proctor, however, thinks that "The builders would require a much more satisfactory north and south line than this," and he asks, "What, at this stage of the proceedings could be more perfect, as a method of obtaining the true bearing of the pole, than to dig a tubular hole into the solid rock, along which tube the pole star at its lower culmination should be visible? Perfect stability," he adds, "would thus be ensured for this fundamental direction-line. It would be easy to obtain the direction with great accuracy even though at first starting the borings were not quite correctly made."—(*The Great Pyramid*, by Prof. R. A. Proctor, New York, 1883, pp. 93, 94.)

All this is true, and it furnishes a plausible explanation of the facts. We can only say of it that a modern engineer would have found means to lay down a line above ground, just as stable, just as accurate, and at vastly less cost of time or labor or money. For it is to be observed that the boring of the tunnel, difficult as that work must necessarily be, is but a first step towards finding the meridian line by this method. The work could not but be difficult, since the cross-section of the tube in the case of the Great Pyramid was but 3 1-2 by 4 feet, while the length was more than 230, and the material was solid limestone, to be actually picked out by tools in the hands of men, unaided by any of the explosives which perform for the modern engineer the heaviest part of his underground work. But after the bore is complete, it is necessary in this process, in order to transfer the north and south line to the surface of the earth, where it is wanted, to make a second and vertical per-

foration at a point judged or computed to be just over the southern termination of the inclined tube, and through this to drop a plumb line, the suspending point of which is to be moved east or west as may be necessary to bring the plummet to the inclined meridian line in the tunnel below.

Now it is easy enough to see that if it had been only desired to fix by stable monuments a meridian line deduced from observation of a circumpolar star, it would have been cheaper and more expeditious to raise a column of masonry a hundred feet high, than to bore out of solid rock a tunnel two hundred and thirty feet long; so that the mode adopted by the Pyramid builders to fix their orientation was not creditable either to their science or to their good sense. Since, however, it is possible, I do not consider it by any means demonstrated, that the tube beneath the Great Pyramid was bored for the purpose asserted, it would seem as if it had fully answered its end before the building began, and that there was no need to continue it through the courses of the rising structure. Mr. Proctor, however, supposes that the observations for orientation continued to be repeated for every additional course; and hence he derives a reason of being for the ascending passage which rises at a similar angle toward the south. For if, just below the junction of the two passages, the descending passage had been stopped up, and the basin thus formed had been partially filled with water, the image of the star at its culmination might have been seen reflected from the surface of the water by an observer in the rising passage; and thus, after the structure, in the progress of building, had been raised above the northern entrance mouth, the observations for orientation might still have been carried on in the manner here suggested, by reflection. Of course, this is possible, but it would hardly seem to have been necessary.

The most important deduction from this theory of the design of the inclined passages, is that it implies the presence of a close circumpolar star in position to be observed through the entrance passage at the time of the erection of the monument. If there was such a star it could not have been our present pole-star, for that has only been brought, by the effect of the slow movement known as the precession of the equinoxes, into position to be entitled to its present distinction within the last few centuries. At a period so comparatively recent as the beginning of our era, it was still distant from the pole more

than twenty-five degrees. By looking on a celestial sphere along the small circle of latitude which is distant about twenty-three and a half degrees from the pole of the elliptic, we may easily find all the stars which have been near the pole during an entire precessional revolution of twenty-five thousand years, and select any which are conspicuous enough to have been regarded at any time as pole-stars. This has been done by the devotees of the Pyramid faith, and the star called Alpha Draconis has been fixed on as the pole-star of the Pyramid.

It becomes, then, a question of the first magnitude in point of importance to ascertain at what time this star may have been seen, by an observer placed far within, to pass the axis of the passage. Prof. Smyth computes the distance which, in order to do this, it should have had from the pole, by comparing the inclination of the passage with the altitude of the pole at the place. The inclination, directly measured, is made by him to be 26° 27′; but, as the ascending passage and the grand gallery have inclinations slightly different, the former being 26° 6′ and the latter 26° 17′ 37″, while it is presumed that the intention was to make them originally equal, he has chosen to take the mean of the three, viz., 26° 17′; and this, subtracted from 29° 59′, the elevation of the pole, gives 3° 42′ for the required polar distance of the star.

The star Alpha Draconis appears to have been first pointed out by Sir John Herschel as the probable pole-star of the Pyramid builders; but the manner in which he attacked the problem was by inquiring, not at what date the star was at a given distance from the pole, but how far the star was actually from the pole four thousand years ago, the computation having been made in 1839. Four thousand years counted backward from this date carries us to the year 2161 B.C. The calculation is given in detail in the Appendix to Col. Howard Vyse's great work on the Pyramids, Vol. II., pp. 108, 109, the resulting polar distance being stated at 2° 51′ 15″. There seems to be some error (perhaps of transcription) here, since, according to our computation, the star had this distance from the pole in 2359 B.C., or about two hundred years earlier than Sir John Herschel makes it. It is true, however, that the star had the polar distance of 3° 42′ in 2175 B.C. (Prof. Smyth makes it 2170 B.C.), so that, in that year, it might have been observed in the axis of the tube at its lower culmination. This, in the opinion of the professor, fixes the date of the foundation of the Pyra-

mid. But there was a much earlier date at which the star was at this same distance from the pole, being then further west in longitude than the pole, as it had, in the other case, been further east. This was in 3503 B.C., a date only about two hundred years later than that assigned by Brugsch to Cheops, and therefore the more probable of the two, if this very doubtful astronomical theory of the Pyramid is to be accepted.

There seems, however, to be no good reason why the inclinations of the interior passages should be taken into account in this calculation. Since the builders have not themselves given us a reason for anything that they did, it is quite possible that the differences found in the inclinations of the several passages were intentional; and such extravagant claims have been made for these operatives in regard to the accuracy of their workmanship, as to make the supposition quite untenable that they could have committed positive errors so large as these differences imply. There remains the hypothesis that the angles originally given to the slopes may have been disturbed by movements of the earth within the past four thousand years. But this seems to be negatived by the observations made in 1865 by Mr. Inglis and Prof. Smyth on the floor-levels of the corner-sockets, which, to their astonishment, appeared to be quite true. Of the north-east corner socket Prof. Smyth remarks: "Mr. Inglis examined it over the whole floor with a spirit level. 'Why, I cannot find any error in it,' said he." (*Life and Work, etc.*, Vol. III., p. 529.) And of the south-east socket he observes (*Ib.*, p. 538): "Besides the astonishing firmness of the foundation, the truth of level was such that on removing from the north-east to the south-east socket there was hardly more than half a turn of any one of the fine-threaded foot-screws to be made to put the instrument level within a second of space." There have been, therefore, no earth movements in Lower Egypt for the past four thousand years. We should, accordingly, take 26° 27′ as the true original inclination of the entrance passage, and should hence seek a date for a polar distance of the star of 3° 32′. But this is of no great practical importance, since it makes a difference of date of only about thirty years.

The probability, however, appears to be that the inclination of the passages had nothing whatever to do with astronomy, and that all the labor that has been expended over the star Alpha Draconis has been thrown away. This probability rests

(1) upon the well known fact that an inclined entrance passage on the north face is a feature common to all the pyramids, which must have an explanation (if it could be found) applicable alike to all. Col. Howard Vyse has given the angles of inclination of the entrances of each of the nine Pyramids of Gizeh, as follows:

NAME.	ANGLE.	NAME.	ANGLE.
Great Pyramid	26° 41′	Sixth Pyramid	30° 00′
Second "	25° 55′	Seventh "	33° 35′
Third "	26° 02′	Eighth "	34° 05′
Fourth "	27° 00′	Ninth "	28° 00′
Fifth "	27° 12′		

To these may be added:

NAME.	ANGLE.
Pyramid of Abou Roash	22° 35′
Great Pyramid of Saccarah	23° 20′
Third " " "	26° 35′
North Stone Pyramid of Dashour	27° 56′
South " " "	26° 10′
North Pyramid of Abouseir	27° 5′
Great " " "	26° 3′

Now if it had been the purpose of the inclined passage of the second pyramid of Gizeh to observe the star Alpha Draconis in its axis, at the lower culmination, since the star would have then been 4° 04′ from the pole, the Pyramid must have been built either in 2111 B.C., that is to say, sixty years later than the Great Pyramid, or in 3567 B.C., that is to say sixty years earlier than the highest and most probable of the dates astronomically indicated for the former. But if anything is settled in Egyptian archæology, it is that these two pyramids were built by two brothers.

Should it be thought that the interval of sixty years is not enough to discredit the belief that these two monuments might be the work of brothers, let us take the Fourth Pyramid, and it may be shown by the same mode of reasoning that this must have been erected as early as 2403 B.C., that is to say more than two hundred years before the Great Pyramid. And in like manner the North Stone Pyramid of Dashour dates back to 2515 B.C., or to about three hundred and fifty years earlier than the Great Pyramid. The Southern Stone Pyramid at the same place would appear to have been erected almost contemporaneously with the Great Pyramid of Gizeh; and this monument has also the interesting feature of a western as well as

a northern entrance, with an angular descent of 26° 36′. Had such a passage been found in the Great Pyramid, we should probably have been instructed that it was intended for observations in the Prime Vertical; though it might have been found difficult to account for its particular angle of inclination.

The entrance passage of the Sixth Pyramid of Gizeh is directed to a point within one minute of the pole. Inasmuch as the star Alpha Draconis, at its closest appulse, is distant from the pole nearly nine minutes, it follows that it can never have been seen in the axis of this passage; although, about the year 2840 B.C., and for a long time before and after, it must have been within the field of view to an observer in that passage throughout the entire twenty-four hours.

There is therefore no good reason for believing that these passages were constructed for astronomical purposes, and their general similarity forces us to believe that their actual purpose, whether we can explain it or not, was everywhere the same. It cannot have been for the orientation of the Pyramids, for though this is generally nearly true, it is not true without exception; the Great Pyramid of Saccarah, according to Col. Vyse, deviating as much as 4° 35′ from the true north and south, and the Third Gizeh Pyramid being out nearly a quarter of a degree.

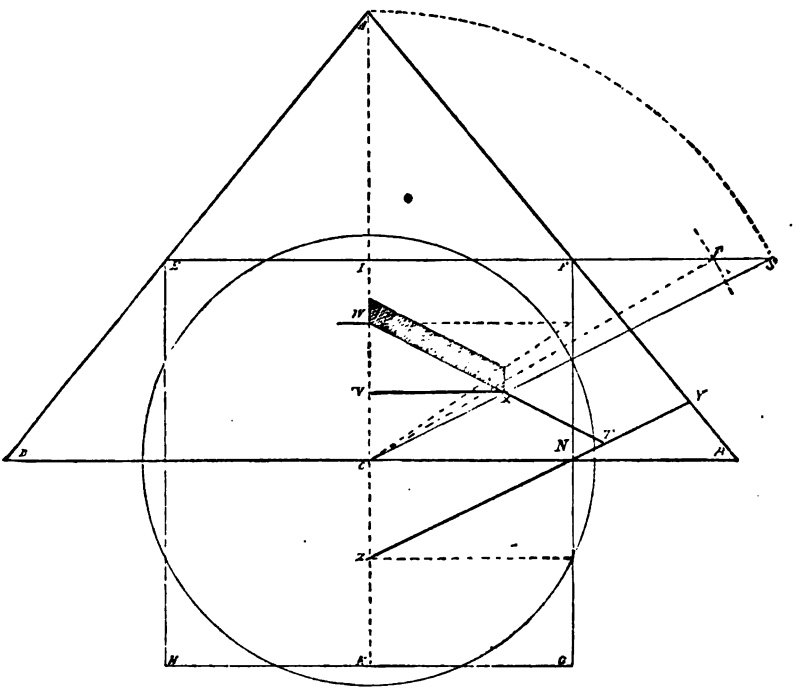
It is to be presumed, however, that the particular inclinations given to the several passages, were determined, as is usual in building to a batter, by the proportion arbitrarily adopted by the builders between base and altitude. In the same way, no doubt, was determined the side slope given to the faces of the Pyramids themselves. Thus the masonry core of the Great Pyramid of Gizeh was apparently built to a batter of four base, to five perpendicular; and the same rule was apparently followed with several of the remaining pyramids of the Gizeh group.

The entrance passages of the first four Gizeh Pyramids were probably built to a batter of two base, to one perpendicular. The exact observance of this rule would give 26° 34′, which is precisely the mean between the measurements of this inclination given by Col. Howard Vyse, as above, *viz.*, 26° 41′, and of Prof. Smyth, *viz.*, 26° 27′. In the practical work of construction, however, measurements would have to be made with severer accuracy than can reasonably be hoped for with

stone masons, in order to secure in the results exact conformity with the trigonometrical indications.

In the Sixth Pyramid the rule may have been eight base, to five perpendicular; and in the Seventh and Eighth five base, to three perpendicular.

The hypothesis above stated in regard to the Great Pyramid is supported by the testimony of Prof. Smyth himself. The subjoined, Fig. 2, is a copy of Fig. 2, Plate VII., given in



LENGTH AND PLACES OF PASSAGES IN THE GREAT PYRAMID.

Trisect *IG* & Bisect *CR* by horizontal lines, then *ZV* parallel to *CS* marks entrance passage. *WT* at an equal but opposite angle marks First Ascending passage and the Grand Gallery. Angle *BCP* (where *CP* = side of equal area square) = 30° = Latitude, approximately.

the work so often quoted in this paper, *viz.*, "Our Inheritance," etc., and designed to illustrate certain geometrical re'ations which do not concern us here. In this figure *ABD* is a vertical meridian section of the Great Pyramid. *EFGH* is a square equal in area to the triangular section, placed with its centre at *C* in the middle of the base, and its sides, *EF* and *GH*, parallel to the same. *CK*, equal to the half side of the square, is bisected in *Z*, making *CZ* equal to one-quarter the

side of the square. Then *CS* is drawn to make the angle *BCS* equal to the inclination of the entrance passage *viz.*, 26° 17′, and *ZY* is drawn parallel to *CS*. *ZY* is then coincident in direction and in position with the entrance passage, and it cuts the base at the point *N*, where the side *FG* of the square also cuts it. Now *CN* is twice *CZ*; that is to say the inclination of the entrance is determined by the mechanical process of building to a batter of two base to one perpendicular. This illustration, moreover, accounts not only for the angle of inclination of the entrance, but for its exact position in the building; and thus demonstrates that its construction was determined, in every particular, by purely geometrical considerations, and without any regard to astronomy at all.

There is but one point in the construction of the Great Pyramid which, in the mind of a man in possession of his sober senses, can justly be regarded as connecting it in any manner with exact science. It is the fact that it appears to possess, or very nearly to possess, that property which has induced Prof. Smyth to give it the name of a π Pyramid—a pyramid, that is to say, in which the perimeter of the base is just equal to the circumference of a circle having the height of the pyramid for a radius. It cannot be said that this point has been fully made out. It has been inferred from measurements of the angular slope of the side of the Pyramid. This angle, if the proposition is true, ought to be equal to 51° 51′ 14.3″. In the present denuded condition of the monument, it is impossible to test the question by direct observation upon the visible faces; but the angles on the casing stones, fortunately found in place by Col. Vyse in 1837, gave by one method of measurement 51° 50′, and by another 51°52′ 15.5″. The mean of these is 51° 51′ 7¾″, which very nearly approaches the exact angle required. Prof. Smyth has endeavored to corroborate this result by many angular observations, made upon both the sides and corners of the monument in its existing state, estimating for the thickness of the casing removed—a very uncertain method—with results which, to him at least, are entirely satisfactory. It is perfectly obvious, nevertheless, that practical builders could never build to an angle like this—the impossibility strikes us the more forcibly when we see how difficult it is by direct measurement of the stones found still in their original condition, to ascertain to what angle they really did build. Practi-

cal stone masons need for their guidance a rule requiring the use of only their ordinary measures of length. If they had built to the batter of four base, to five perpendicular, the result would have been a slope of 50° 21′ nearly. If they had used the rule of twenty-five base, to thirty-two perpendicular, the slope would have been 52°.

The builders seem to have been guided by a rule resembling one of these—probably by the first, corrected and checked by a more exact rule applied at the corners. For it has been noticed that the angle of the corners is exactly that corresponding to a base of ten and a perpendicular of nine, from which is deduced a lateral slope of 51° 50′ 39″, differing from the required π inclination by only 35.3″. Now it has been very plausibly suggested by Col. Sir Henry James, that the building process was probably conducted by first setting out the courses at the angles in accordance with the rule of ten base, to nine perpendicular, and then carrying the courses along the sides by line and level. The resulting height of the Pyramid constructed by this process, as compared with that of a true π Pyramid of the same base, is given by Prof. Smyth in Pyramid inches, as follows: "Using the same base side length (9131 Pyramid inches) for both—by the 10 : 9 hypothesis, 5811 by the π hypothesis, 5813," showing a difference of only two Pyramid inches—that is to say, a quantity quite imperceptible in so enormous a mass. There can therefore be no doubt that the process by which the Pyramid was actually erected was that which is here described, and that, if the Pyramid is, as it very probably is, a π Pyramid, it is so by accident.

In conclusion, it is impossible not once more to revert to the singular fact that, if all the wonderful things are true of the Pyramid that have been asserted of it, not one scintilla of evidence has been produced to show that any one of them was ever in the mind or the intention of the builders at all. If they had intended, as Mr. Taylor says they did, to make this structure "a record and a memorial to the end of time of the Measure of the Earth;" if they had intended to convey to posterity, by means of it, a knowledge of the exact length of the earth's axis, of the exact number of days in the tropical year, of the exact error of the British inch, of the exact number of inches in the sacred cubit, of the exact distance of the earth from the sun, of the earth's exact mean temperature, of its exact specific gravity, and of the exact ratio of the radius of the

circle to its circumference, it exceeds all the bounds of reasonable credulity to suppose that they would fail to leave—not to say a clear, distinct, and unmistakable enunciation of such a purpose—but the slightest trace, character, emblem or token of any kind, to bear witness to their intention.

But the case is far stronger than this. Not only have they furnished us voluntarily no evidence of a design on their part to convey a message to posterity, not only have they failed to give us a hint of their possession of any important knowledge which they might convey if they would, but they have endeavored to prevent, by means the most effectual which they knew how to employ, any discovery by future generations of the secrets, whether important or trivial, which they had locked up in the heart of this mountainous mass of stone. Not only was the external opening of the single entrance passage so carefully closed up that it remained undiscovered for an unknown number of centuries, but the passage branching from this and leading to the chamber containing the only object of interest in the whole structure, was plugged up at its lower extremity with blocks of solid granite measuring in section about three and a half feet by four, and fifteen feet in total length; which were made tapering so as to fit closely, like a massive wedge, into a passage similarly tapering, and into which they were let down from above, and strongly cemented as well as driven. The point of the entrance passage at which this ramification took place was also carefully concealed, by closing the opening with a triangular block of stone like that which forms the facing of the passages, and made to appear on the interior to be a continuation of the facing. Nothing can be more palpably evident than that it was the determined purpose of the constructors of this monument not only not to inclose in its secret chambers any messages of any kind whatever to future generations, but to render it practically impossible that anything shut up in those chambers should ever be known to mankind to the end of time. Their measures were judiciously taken. It was no fault of theirs that they proved ineffectual at last.

I have met with some persons who, while they have felt sensibly the absurdity of the pretensions set up on behalf of the Pyramid, have nevertheless appeared to be considerably shaken by the numerous coincidences which its theory seems to present with certain well ascertained truths, such as for in-

stance, the near approach to a decimal relation between the British inch and the axis of the earth, the approach to a similar relation between the height of the Pyramid and the distance of the sun, the position of the star Alpha Draconis four thousand years ago, the approximate equality of the obsolete British chaldron, and the computed capacity of the coffer; these, and other things like them, constitute a combination of analogies which such persons can hardly bring themselves to regard as wholly accidental. But from what has been said above, it has been made, I trust, to appear that the coincidences here assumed to exist are in some cases really non-existent; that in other cases they are far from being so close as asserted, and that in other cases still (as in the π property of the Pyramid) they are capable of very simple explanation, and are strictly accidental in the sense that the result was not intended or anticipated by the producer.

But in order to show how easily a system like that which I have called the theory of the Divine Legation of the Pyramid, may be built up out of the most unpromising material, I will make a supposition. Ephesus, a city of Asia Minor, consecrated to Diana, was one of the most splendid of the Grecian cities of antiquity. Its principal temple, erected to its patron goddess, was of so surpassing magnificence as to have been assigned a place among the seven wonders of the world. This splendid edifice, originally founded in the last year of the fifty-sixth Olympiad, after having stood for nearly two hundred years, was willfully fired by a miscreant named Herostratus, who avowed under torture, that the only motive for his crime was the hope to immortalize his own memory. After the battle of Ipsus, in the third year of the 119th Olympiad, Lysimachus, one of the allied victorious commanders, got possession of Ephesus, and commenced a reconstruction of the city nearer the site of the temple, which had been erected without the walls at a distance of seven stadia. The rebuilding of the temple was a part of this scheme of reconstruction, and this was early commenced, but was not brought to completion for more than two centuries. In A.D. 262, this new temple was once more destroyed by the Goths, and its ruins became a quarry of material for modern buildings, out of which cities so far off even as Constantinople drew supplies. So complete, with the lapse of time, was the disappearance of this once majestic architectural pile, that there remained at length not

a trace of its existence above ground, and the very site where it had stood became matter of doubtful conjecture.

It is now fifteen or twenty years since Mr. J. T. Wood, an architect in the service of the British government, entered upon a series of explorations of the points in and about Ephesus which seemed to promise to throw light upon its ancient history He succeeded in uncovering the foundations, beneath more than seven feet of earth, of the latest temple, and under this those of two others, the earliest at a depth of twenty feet, but all of equal dimensions. He also unearthed the foundations of a great theater, and those of an Odeon, or Music Hall, all of unknown antiquity. Of these several edifices he took measures as well as he could, and these measures are what interest us at present.

He found the temple to be 343 British feet long, and 164 feet wide; the theater to be 495 feet in diameter, and the Odeon 153 feet. I propose to treat these measurements as Prof. Smyth has treated those of the Pyramid. And, in the first place, in order to make the parallel complete, I must suppose that other visitors have followed Mr. Wood, and have made independent measurements of the same constructions. We should naturally look for differences in any case; but in this case the situation of the object must have made the measurement unusually difficult and doubtful. I would not intimate that all the difference between Pliny, who reports the dimensions of the temple as 425 and 220, and who wrote in the first century, A. D., and Mr. Wood, whose results are given above, is due to the inaccuracy of the British architect entirely, for I presume the Roman wrote from hearsay; but it is a fact of common observation that different tourists who visit many other objects besides the Pyramids, give us often very discordant reports of the dimensions of such as they profess to have measured with their own hands. Prof. Smyth has found that even men usually so exact as the French academicians, Messrs. Jomard and Denon, were capable of committing a grave error—an error amounting to several inches—in so simple a measurement as that of the height of the coffer in the King's Chamber.

I suppose, then, that the length of the Ephesian temple has been measured by four different visitors besides Mr. Wood, and that their results are 342.6 ft., 343.7 ft., 344.3 ft., and 344.9 ft. These with Mr. Wood's 343 ft. give a mean of 343.7 ft., as

the most probable length. Reduced to inches this gives us 4,124.4.

Now, considering that this temple was consecrated to Diana, who is, in other words, Luna, or the moon, and having been taught by Prof. Smyth, how the dimensions of the Pyramid are mixed up with the days of the year and the axis of the earth, I feel satisfied that we must have something of the same kind here; only that, instead of the days of the year we ought to have the days of the lunation, and instead of the axis of the earth we ought to have the axis of the moon. The lunation is about 29½ days long, and accordingly I divide 4,124.4 by 29, and I find the quotient to be a little over 14 multiplied by 10. Fourteen inches, therefore, I conjecture to be, probably contained "a round decimal number" of times in the moon's diameter. I proceed to test this probability.

It is to be considered that when this temple was built the magnitude of the moon could have been but imperfectly known. Though the nearest to us of all the heavenly bodies, the determination of its dimensions must, in the infancy of astronomy, have presented peculiar difficulties. It is a problem involving three independent elements, no one of them easily ascertainable—the moon's mean apparent angular diameter, her mean equatorial horizontal parallax, and the earth's equatorial diameter. Many of the estimates or computations of this quantity twenty-five hundred years ago (since the Ephesians, being heathens, could have had no supernatural light to guide them) must have gone wide of the mark. We know this value now with all desirable accuracy. It is very close to 2160 English miles. But, in the fifty-sixth Olympiad, estimates must have varied through a range as wide as from 2000 to 2400 miles, or even wider. We may assume, therefore, 2205 miles as a probable mean between these estimates. This reduced, gives 11,642,400 feet, or 139,708,800 inches.

I see, then, that the ten-millionth part of the moon's diameter is equal to 13.97 British inches, and I call this ten-millionth part a *lunar cll.*

I will now suppose that some one of the explorers whom I have imagined to have followed Mr. Wood, has found in a cavity of some hollow masonry, the interior of which has been exposed to view in the progress of decay, a measuring rule uniformly divided, and evidently one of those used by the builders, but which had been accidentally left there and forgotten.

I will suppose the divisions to be twenty-eight in number, and the total length to fall short of twenty-eight English inches by about six one-hundredth parts of an inch—in short, that it measures 27.94 inches. It is distinctly divided in the middle into two equal parts; and each part is further subdivided into fourteen equal divisions. I call these divisions lunar inches. The rule is evidently a double lunar ell; and the lunar ell contains fourteen lunar inches, each of which is equal to $1\frac{33}{466}$ of an English inch; or is short of the English inch by the 467th, or nearly the 500th part.

If it should be objected that there is no such measure as a lunar ell in the metrological system known to have been in common use among the Greeks, the reply naturally presents itself that this measure was not in common use—that it was a sacred measure employed only in constructions connected with the worship of the Moon, and perhaps even in that use confined to the sacred city of Ephesus.

I have a suspicion that the length of the temple must contain a number of lunar ells which is probably a multiple of the number of days in the lunar month. In order to test this hypothesis I propose to find the number of lunar ells in 343.7 feet English. But remembering that the British inch exceeds the lunar inch by about one five-hundredth part, I first increase 343.7 by 0.6874 ft., the quotient of a division by 500, which gives a total of 344.3874. This number of feet becomes lunar ells by subtracting one-seventh part; inasmuch as a foot is six-sevenths of a lunar ell. One-seventh part of 344.3874 is 49.1972; and, the subtraction being made, there remain 295.1902 lunar ells. Now the lunar month contains 29.5306 days, so that the length of the temple appears to contain ten times as many lunar ells as there are days in the lunar month.

In order to make the comparison a little more exact, let us calculate how many English inches there are in as many lunar ells as the lunar month contains days. In English inches 13.97 is the value of a lunar ell. And $13.97 \times 29.5306 = 412.5425$. Also 343.7 English feet contain 4124.4 English inches; the tenth part of which is 412.44, identical with the former result to the tenth of an inch. It is therefore very clearly established that the intention of the builders of this temple was to make its length ten times the ten-millionth part of the Moon's diameter multiplied into the number of days of the lunar month. Or, to paraphrase the manner of speaking of Prof. Smyth, it is

"equivalent to the architect having laid out the length of the temple with a measuring rod fourteen inches long in his hand, and in his head the number of days and parts of a day in a lunation multiplied by ten, coupled with the intention to represent that number of days in terms of that rod" in the largest dimension of the temple.

The division of the lunar ell into fourteen parts has a natural explanation. The Asiatic Greeks, like all other eastern peoples, were worshippers of the heavenly host; and though the Ephesians paid their chief devotion to Diana, they were not unmindful of the divinities associated with the other wandering stars. Of this class there were known to them only seven, viz.: The Sun, the Moon, Mercury, Venus, Mars, Jupiter and Saturn. Of these, two were the greater, and the remaining five the lesser lights. The number *seven* was, therefore, a number held in special reverence; and this number multiplied by two, the number of the greater lights, gave fourteen, the number of lunar inches into which the lunar ell was divided.

The numbers *two*, *five* and *seven* appear all to have been held in reverence by the Ephesians, the first as representing the greater lights of the heavens, the second as significant of the lesser lights, and the third as standing for the whole solar system so far as it was known to them. Their multiples naturally shared this distinction, as is illustrated in the lunar ell, and in the fact stated by Mr. Wood that the entrance to the temple is made by fourteen steps. Thus also is explained the partiality shown for round decimal numbers.

The breadth of the temple, determined in the same manner as the length, by taking a mean of several presumed measurements, may be put at 161.53 English feet, which would be equivalent to 161.85 lunar feet; the diameter of the Odeon at 151.862 English or 152.185 Ephesian, and the diameter of the theatre at 493.73 English or 494.72 Ephesian.

It seems to have been the intention of the builders to make the breadth of the temple ten times the lunar ell multiplied by the sacred number fourteen. The number of inches in 161.85 lunar feet is 1942.20. If we take the breadth at 163.3 (which would be "among" the measurements) we should obtain a result of 1959.6. But $14 \times 14 \times 10 = 1960$.

There is, however, a curious relation between the temple and the Odeon, involving also the length of the sidereal year. It is that the area of the temple floor is equal

to the area of a rectangle of which one side is the diameter of the Odeon, and the other the number of sidereal days, integral and fractional, in the year, with an error of only about three ten-thousandth parts of a day. Thus 344.3874 × 161.85 = 55,739.10069 square feet, which number divided by 152.185 gives as a quotient 366.2588; the true length of the sidereal year being 366.2591.

The diameter of the Odeon seems also to connect the twenty-four hours of the day with the true length of the tropical year, for it appears that 152.185 multiplied by 24 gives, as a product, 365.244—a value in excess of the true value by two one-thousandths of a day.

The diameter of the theatre appears to have been designed to denote the date of the erection of the building. In a city consecrated to Diana it was natural that time should be reckoned by the lunar year. Such was the practice among all the early Greeks, those in Europe as well as those in Asia, as it was among the Egyptians, Jews, and Asiatics generally. The theatre was therefore founded sometime during the 495th lunar year counting from the common epoch, *i. e.*, from the beginning of the first Olympiad, 776 B. C. In order to find the corresponding solar year we must first ascertain the length of this year expressed in lunar months, by dividing 365.2422 by 29.5306, which gives us 12.368 as the number of lunar months in the tropical year. We state then the proportion, as 12.368 is to 12, so is 494.72 to a fourth term, which we find to be exactly 480. We conclude, therefore, that the theatre was founded in the 480th year from the epoch, which places the foundation in the last year of the 120th Olympiad, or in the fifth year after the reconstruction of the city was undertaken by Lysimachus.

This measure seems also to have been intended to embody the length of the mean lunation, for, on reducing it to inches and dividing by 29.5306, the number of days in the lunar month, we obtain a quotient of 201.00; that is to say almost exactly 200, or a number compounded of the round decimal multiple 100, and the sacred number 2. Probably, if we had an entirely correct measurement, the coincidence would be complete.

Furthermore, if we multiply the days of the tropical year by the sacred number 14, we shall obtain a product of 5113.3902. And if we suppose the theatre to have had a pro-

pylon in front, as it must have had, of say 16.62 feet in breadth, the entire measure, propylon included, multiplied by 10, will be the same, *viz.*, 5113.4.

These coincidences are sufficient to show that the Ephesians had very early become extremely proficient in astronomy, and that they had a fancy very much like that of the ancient Egyptians, which led them to build their astronomy (and we may add their piety) into their monuments. I regret that I have not a larger number of measurements for study and comparison. I cannot doubt that the results would be equally interesting. Unfortunately, I have not at hand Mr. Wood's full account of his discoveries. The foregoing particulars are derived from an article contributed by him to one of our cyclopædias.

But the most curious fact brought to light by this inquiry is that the lunar ell, taken as many times as there are days integral and fractional in the lunar month, gives a result which, reduced to English inches, is exactly 412.5425; while the length of the King's Chamber in the Great Pyramid, as determined by the mean of the very careful measurements of Prof. Smyth, made on both sides, is 412.54. This measure, which in its relations to the Pyramid is very important, I propose to call a lunar metron. As the breadth of the King's Chamber is half a metron, the whole perimeter is equal to three metra, representing one season of three lunar months. Reduced to Pyramid inches the metron becomes 412.13, a quarter part of which, *viz.*, 103.033, being the half breadth of the King's Chamber, figures in Prof. Smyth's calculations in so many ways that it is called by him "the unit test of the King's Chamber."

This unit test is contained twice in the breadth of the King's Chamber, four times in its length, and five times in its solid diagonal. It is exactly the length of the granite portion of the floor of the antechamber, and the height of the granite wainscot on the east side of the same. Multiplied by one hundred, it is the diameter of a circle whose area is just equal to that of the square base of the Pyramid. One half of this, *viz.*, 5151.65, is the side of a square equal to a vertical triangular section of the Pyramid, and also to a circle having a diameter equal to the Pyramid's height. And as the hundredth part of the Pyramid's height doubled is equal to 116.26 Pyramid inches, which is the entire length of the antechamber floor, while 103.033 is the length of the granite part of it only, it follows that the

floor represents at the same time the side of a square and the diameter of a circle of equal area. "Or, as the Abbe Moigno" (we quote from *Our Inheritance*, etc., p. 187, in *Les Mondes*) "more elegantly puts it (having previously called $116.26 = 2r$, and $103.033 = c$): this remarkable employment of granite and limestone by the ancient Pyramid architect is the method adopted by him of saying, in the common language of mathematical science, from an isolated mountain peak of 4,000 years ago, to all nations in the present educated age of the world, that

$$\pi r^2 = c^2."$$

This is undoubtedly eloquence, but unfortunately the announcement comes at a time when it can be of no possible use, the fact stated having been well known to the world for several centuries. "Who," says the Abbé, "after this first coincidence of the antechamber, could pretend that the diversity of the materials and their relations, or *differences*, of length, are a simple brute accident?" Well, nobody, perhaps; but whoever imagines they are *not*, must, I think, be constrained to believe that the cunning contrivers of these ingenious scientific puzzles were not disciples of Melchizedek at all, but mere miserable heathen worshippers of Isis. For Isis was the Egyptian personification of the Moon; and the builders of the Pyramid were evidently acquainted with the lunar inch, the lunar ell, and the lunar *metron*; for they employed these measures not only in the King's Chamber, but throughout the entire structure.

Still one can suppose that the differences of length in the floor of the antechamber were not "a simple brute accident," without going so far to account for them as the worthy Abbé and his friend, Prof. Smyth, are supposed to do. It is a fact that the diameter of a circle and the side of its equivalent square are proportioned to each other very nearly as nine to eight. Eight-ninths of the length of the floor of the antechamber were laid down in granite, and the remaining one-ninth in limestone. Eight-ninths of 116.26 inches (the total length) is 103.342, which differs from the length of the granite portion as derived from measurement, only three-tenths of an inch. The constructors were probably not thinking of squares or circles at all.

One-tenth of the metron is the exact breadth of the entrance

passage and of the first ascending passage. Two-tenths is the breadth of the grand gallery; one-tenth is the distance between the ramps of the gallery, and one-twentieth is the breadth of each ramp. The length of the Queen's Chamber is half a metron, and the height of its walls appears to have been intended to be in the mean the same, though the roof is gabled, and the measurements vary between 182 at the side walls, and 244 at the vertex of the gable. Finally, the side of the base of the Pyramid itself was probably laid out of a length of 220 metra; since 220×412.54 gives a result nearly approaching the base measurement of Mr. Inglis.

It appears, therefore, to be pretty clearly demonstrated that, if any religious considerations entered into the construction of the Pyramid, they were connected with the worship of Isis. And this hypothesis derives a high degree of plausibility from the historical fact that the Egyptians were a remarkably religious people.

I venture therefore to propose a new theory of the Pyramid, which may, with propriety, be styled a lunar theory. It is supported by evidence quite as striking as that which is adduced in favor of the theory of the divine legation, and of precisely the same kind. It is, as the other is not, entirely in harmony with what we know of the character of the ancient Egyptians, and it dispenses with the violent hypothesis of the invasion and subjugation of their country, and the cruel oppression of its inhabitants by a migratory multitude coming from the distant plains of Shinar, to fulfill a pious mission with arms in their hands. I do not anticipate the early or general acceptance of my theory. I content myself with the conviction that it is worthy to be accepted—or at least *as* worthy of acceptance as any which has been heretofore promulgated. And if I shall, though failing of such signal success, accomplish only so much as to induce some of my fellow men to apply a little common sense to the study of a subject which has been heretofore involved in an elaborate web of ingeniously contrived mysticism, I shall feel that my labor has not been wholly thrown away.

POSTSCRIPT.

Since the foregoing paper was presented to the American Metrological Society, I have met with a recent work on the Pyramids and Temples of Gizeh, Mr. W. M. Flinders Petrie.

Had I made acquaintance with this book earlier, I should have spared myself the trouble I have taken; for, by the array of new facts which it presents, it demolishes completely the pretensions of the Pyramid religion, and buries, beyond all hope of resurrection, the ingenious theories of Mr. John Taylor and Prof. Piazzi Smyth.

But this is not what Mr. Petrie went to Egypt to do. When he visited Gizeh, his object was to carry out some lines of research which had been indicated by Prof. Smyth as still desirable in order to the more full confirmation of the theory set forth in his works. In his earlier life the author had been himself a true believer, and as the son of Mr. William Petrie, whose valuable contributions to the Pyramid theory are so frequently referred to, and so warmly commended by Prof. Smyth, he was necessarily trained from infancy in the orthodox faith. He manifested, in fact, so long ago as 1874, the sincerity and depth of his earlier convictions, by publishing a collection of "Researches on the Great Pyramid," evincing much study and labor, and prefaced in these words:

"The following researches on this monument confirm those distinctive principles of its design and construction first announced by the sagacity of John Taylor and Professor Piazzi Smyth, as they were set forth in Prof. Smyth's first publication on the subject, 'Our Inheritance in the Great Pyramid,' first edition, published just ten years ago. The many fresh facts here noticed, while showing much further and interesting development of those principles, add irrefragable proof of their validity as against superficial theories, old and new."

It will be admitted that very thick scales must have fallen from the eyes of the man who wrote that before he could see clearly to pen the following closing paragraph of his new work:

"As to the results of the whole investigation perhaps many theorists will agree with an American who was a warm believer in Pyramid theories when he came to Gizeh. I had the pleasure of his company for a couple of days, and at our last meal together he said to me, in a saddened tone, 'Well, sir, I feel as if I had been to a funeral. By all means let the old theories have a decent burial, though we should take care that, in our haste, none of the wounded ones are buried alive.'"

Mr. Petrie took up his residence at Gizeh in December, '80, and between that time and April, 1882, devoted nine

months of continuous work in making careful measurements of all the monuments of the group, and conducting a trigonometrical survey of the entire plateau. It would be impracticable to give here in detail the results reached by him affecting Pyramid theories; neither is it necessary, for no one who has been particularly interested in the subject will fail to read this book. I will content myself with citing two only of these results: the two which affect most vitally the inspiration theory of the Pyramid, viz., the dimensions of the Pyramid's base, and the cubic capacity of the coffer.

The length of the Pyramid's base side was determined by Mr. Petrie as Prof. Smyth might have determined it, and ought to have determined it, trigonometrically. He found the four sides equal, with a maximum difference from the mean of all the measurements of only about an inch. The north and south sides, between which the apparent difference is only a tenth of an inch, seem to be slightly in excess of the east and west; but the form of the base is sensibly a square. The side of this square has been hitherto the unknown quantity in the Pyramid religion, but it has been a fundamental article in the creed that it should measure just 9,140 British inches. By the inexorable laws of trigonometrical science it is proved to measure, in fact, only 9,068.8 British inches. With this determination, the beautiful union of the sacred cubit and the length of the tropical year melts away into thin air, to be heard of no more among men.

As to the coffer, its capacity is 71,960 cubic British inches; whereas, in order that it may be equal to the tenth part of a double sacred cubit cubed and multiplied by 5.7, it ought to be equal only to 71,464 cubic British inches, or to 71,250 cubic Pyramid inches. The error is only 500 cubic inches, but it is quite enough to secure for the standard unit of the Pyramid metrological system an early place far away in the limbo of forgotten things.

The cube root of 71,960 is 41.594, which exceeds the Karnak double cubit of 41,472 by 0.122, or hardly an eighth of an inch. This approach to coincidence is sufficiently near to make it probable that the constructors, if they were aiming at any determinate capacity, had in view the cube of a double royal cubit. Working in so difficult a material and in so early an age of human history, it should rather surprise us that their error was so small, than that it is so large.

The true measure of the base, while it does away with the fanciful notion of sacred cubits and days of the year, seems to suggest another possibility which, though it may be esteemed quite as fanciful, must nevertheless, if true, be regarded as no less honorable than that to early Egyptian science. The base of the hyperbolic system of logarithms (usually represented by the character ε) is 2.71828. Let this number denote Pyramid inches, and it may be called an Egyptian palm. Then ten Egyptian palms will be 27.1828 Pyramid inches, approaching nearly to the Russian measure of length called an archine (pronounced *arsheen*) of 28 English inches exactly: and which may therefore be called a Pyramid archine. We are now to suppose certain numbers, from their relations to certain geometrical solids, to have been regarded as type numbers. Thus, if we take 1,000 as the type of the cube, 523⅜ becomes that of the corresponding sphere, 500 that of the triangular prism or wedge, and 333⅓ that of the Pyramid.

The north side of the great Pyramid has been found by Mr. Petrie to measure 9,069.5 English inches. Let us take this to the nearest even inch, 9,070, and reduce it to Pyramid inches by subtracting, according to Prof. Smyth's rule, the one thousandth part; the result will be 9,060.93 Pyramid inches.

Now my hypothesis is that the dimensions of the Pyramid's base were determined by making the side equal to the Pyramid archine taken as many times as there are units in the Pyramid type number. Thus, $27.1828 \times 333\frac{1}{3} = 9{,}060.93$, which is precisely the number of Pyramid inches found in this dimension as actually measured.

Had a discovery of this kind been made in the treatment of the orthodox, but unhappily fallacious, measurements of this monument on which the Pyramid religion has been founded, no doubt it would have been announced with great exultation, as a convincing evidence of the high degree of advancement in mathematical science which had been attained by the builders of the Pyramid, or of the preternatural light by which their hands had been guided.

I have already pointed out in the foregoing paper, the evidence furnished by the computed capacity of the coffer, of the knowledge possessed by these same architects of our common system of logarithms. This evidence disappears with the more exact measurement and computation of Mr. Petrie; but in

its place arises the much more startling proof just given of their familiarity with the more interesting logarithmic system which, after their time, must have been lost to the world for some thousands of years, and was only re-discovered so late as the seventeenth century of the Christian era, by the ingenuity of Baron Napier.

This coincidence is so suggestive, that I am almost tempted by it to make a study of all the remaining measures of the Pyramid which Mr. Petrie has now at last given us correctly. Time fails me, however, and I must content myself with making a present of this discovery of mine to the apostles of the ancient Pyramid faith, with the expression at the same time of the hope, that they may find in it the fruitful germ of a new body of doctrine, to take the place of that which Mr. Petrie has so remorselessly swept away.

THE DEPOSITION OF ORES.

By J. S. NEWBERRY.

MINERAL VEINS.

In the QUARTERLY for March, 1880, a paper was published on "The Origin and Classification of Ore Deposits," which treated, among other things, of mineral veins. These were grouped in three categories, namely, 1. Gash Veins; 2. Segregated Veins; 3. Fissure Veins; and were defined as follows:

Gash Veins: Ore deposits confined to a single bed or formation of *limestone*, of which the joints, and sometimes planes of bedding, enlarged by the solvent power of atmospheric water carrying carbonic acid, and forming crevices, galleries, or caves, are lined or filled with ore leached from the surrounding rock; *e.g.*, the lead deposits of the Upper Mississippi and Missouri.

Segregated Veins: Sheets of quartzose matter, chiefly lenticular and conforming to the bedding of the enclosing rocks, but sometimes filling irregular fractures across such bedding, found only in metamorphic rocks, limited in extent laterally and vertically, and consisting of material indigenous to the strata in which they occur, separated in the process of metamorphism; *e.g.*, quartz ledges carrying gold, copper, iron pyrites, etc., in the Alleghany Mountains, New England, Canada, etc.

Fissure Veins: Sheets of metalliferous matter filling fissures caused by subterranean force, usually in the planes of faults, and formed by the deposit of various minerals brought from a lower level by water, which under pressure and at a high temperature, having great solvent power, had become loaded with matters leached from different rocks, and deposited them in the channels of escape as the pressure and temperature were reduced.

Since that article was written a considerable portion of several years has been spent by the writer continuing the observations upon which it was based. During this time most of the mining centres of the Western States and Territories, as well as some in Mexico and Canada, were visited and studied with more or less care. Perhaps no other portion of the earth's surface is so rich in mineral resources as that which has been covered by these observations, and nowhere else is to be found as great a variety of ore deposits, or those which illustrate as well their mode of formation. This is so true that it may be said without exaggeration that no one can intelligently discuss the questions that have been raised in regard to the origin and mode of formation of ore bodies without traversing and studying the great mining belt of our Western States and Territories.

The observations made by the writer during the past four years confirm in all essentials the views set forth in the former article in the QUARTERLY, and while a volume might be written describing the phenomena exhibited by different mines and mining districts, the array of facts thus presented would be, for the most part, simply a reinforcement of those already given.

The present article, which must necessarily be short, would hardly have a *raison d'être* except that it affords an opportunity for an addition which should be made to the classes of mineral veins heretofore recognized in this country, and it seems called for by the recent publication of theories on the origin of ore deposits, which are incompatible with those hitherto presented and now held by the writer, and which, if allowed to pass unquestioned, might seem to be unquestionable.

BEDDED VEINS.

Certain ore deposits which have recently come under my observation appear to correspond very closely with those that

Von Cotta has taken as types of his class of "bedded veins," and as no similar ones have been noticed by American writers on ore deposits they have seemed to me worthy of description.

These are zones or layers of a sedimentary rock, to the bedding of which they are conformable, impregnated with ore derived from a foreign source, and formed long subsequent to the deposition of the containing formation. Such deposits are exemplified by the Walker and Webster, the Piñon, the Climax, etc., in Parley's Park, and the Green-Eyed Monster, and the Deer Trail, at Marysvale, Utah. These are all zones in quartzite which have been traversed by mineral solutions that have by substitution converted such layers into ore deposits of considerable magnitude and value.

The ore contained in these bedded veins exhibits some variety of composition, but where unaffected by atmospheric action, consists of argentiferous galena, iron pyrites carrying gold, or the sulphides of zinc and copper containing silver or gold, or both. The ore of the Walker and Webster, and the Piñon is chiefly lead-carbonate and galena, often stained with copper-carbonate. That of the Green-Eyed Monster—now thoroughly oxidized as far as penetrated—forms a sheet from twenty to forty feet in thickness, consisting of ferruginous, sandy or talcose, soft material carrying from twenty to thirty dollars to the ton in gold and silver. The ore of the Deer Trail forms a thinner sheet containing considerable copper, and sometimes two hundred to three hundred dollars to the ton in silver.

The rocks which hold these ore deposits are of Silurian age, but they received their metalliferous impregnation much later, probably in the Tertiary, and subsequent to the period of disturbance in which they were elevated and metamorphosed. This is proven by the fact that in places where the rock has been shattered, strings of ore are found running off from the main body, crossing the bedding and filling the interstices between the fragments, forming a coarse stock-work.

Bedded veins may be distinguished from fissure veins by the absence of all traces of a fissure, the want of a banded structure, slickensides, selvages, etc.; from gash veins and the floors of ore which often accompany them, as well as from segregated veins, they are distinguished by the nature of the enclosing rock, and the foreign origin of the ore. Sometimes the plane of junction between two contiguous sheets of rock has been the channel through which has flowed a metalliferous

solution, and the zone where the ore has replaced by substitution portions of one or both strata. These are often called blanket veins in the West, but they belong rather to the category of contact deposits as I have heretofore defined them. Where such sheets of ore occupy by preference the planes of contact between adjacent strata, but sometimes desert such planes, and show slickensided walls, and banded structure, like the great veins of Bingham, Utah, these should be classed as true fissure veins.

THEORIES OF ORE DEPOSIT.

The recently published theories of the formation of mineral veins, to which I have alluded, are those of Prof. von Groddek[1] and Dr. Sandberger,[2] who attribute the filling of veins to exudations of mineral solutions from the wall rocks (*i. e.*, lateral secretions), and those of Mr. S. F. Emmons,[3] and Mr. G. F. Becker,[4] who have been studying, respectively, the ore deposits of Leadville and of the Comstock, by whom the ores are credited to the leaching of adjacent *igneous* rocks.

The lack of space must forbid the full discussion of these theories at the present time, but I will briefly enumerate some of the facts which render it difficult for me to accept them.

First, *The great diversity of character exhibited by different sets of fissure veins which cut the same country rock*, seems incompatible with any theory of lateral secretion. These distinct systems are of different ages, of diversified composition, and have evidently drawn their supply of material from different sources. Hundreds of cases of this kind could be cited, but I will mention only a few; among others the Humboldt, the

[1] Die Lehre von den Lagerstätten der Erze, von Dr. Albrecht von Groddek, Leipsic, 1879.

[2] Untersuchungen über Erzgänge, von Fridolin Sandberger, Wiesbaden, 1882.

[3] Geology and Mining Industry of Leadville, Annual Report, Director U. S. Geol. Surv., 1881.

[4] Geology of the Comstock Lode and Washoe District, G. F. Becker, Washington, 1883.

It is but justice to Messrs. Becker and Emmons to say that theirs are admirable studies, thorough and exhaustive, of great interest and value to both mining engineers and geologists, and most creditable to the authors and the country. No better work of the kind has been done anywhere, and it will detract little from its merit even if the views of the authors on the theoretical question of the sources of shall not be generally adopted.

Bassick and the Bull Domingo, near Rosita and Silver Cliff, Colorado. These are veins contained in the same sheet of eruptive rock, but the ores are as different as possible. The Humboldt is a narrow fissure carrying a thin ore streak of high grade, consisting of sulphides of silver, antimony, arsenic and copper; the Bassick is a great conglomerate vein containing tellurides of silver and gold, argentiferous galena, blende and yellow copper; the Bull Domingo is also a great fissure filled with rubbish containing ore chimneys of galena with tufts of wire silver. I may also cite the Jordan, with its intersecting and yet distinct and totally different veins; the Galena, the Neptune, and the American Flag, in Bingham Cañon, Utah; and the closely associated, yet diverse system of veins, the Ferris, the Washington, the Chattanooga, the Fillmore, etc., in Bullion Cañon, at Marysvale. In these and many other groups which have been examined by the writer, the same rocks are cut by veins of different ages, having different bearings, and containing different ores and veinstones. It seems impossible that all these diversified materials should have been derived from the same source, and the only rational explanation of the phenomena is that which I have heretofore advocated, the ascent of metalliferous solutions from different and deep-seated sources.

Another apparently unanswerable argument against the theory of lateral secretion is furnished by the cases *where the same vein traverses a series of distinct formations, and holds its character essentially unaffected by changes in the country rock.* One of many such may be cited in the Star vein at Cherry Creek, Nevada, which, nearly at right angles to their strike, cuts belts of quartzite, limestone, and slate, maintaining its peculiar character of ore and gangue throughout.

This and all similar veins have certainly been filled with material brought from a distance, and not derived from the walls.

LEACHING OF IGNEOUS ROCKS.

The arguments against the theory that mineral veins have been produced by the leaching of superficial *igneous* rocks are in part the same as those already cited against the general theory of lateral secretion. They may be briefly summarized as follows:

1. Thousands of mineral veins in this and other countries

occur in regions remote from eruptive rocks. Into this category come most of those of the eastern half of the Continent, viz., Canada, New England, the Alleghany belt, and the Mississippi Valley. Among these I will refer only to a few selected to represent the greatest range of character, viz., the Victoria lead mine, near Sault Ste. Marie, the Bruce copper mine on Lake Huron, the gold-bearing quartz veins of Madoc, the Gatling gold vein of Marmora, the Acton and the Harvey Hill copper mines of Canada, the copper veins of Ely, Vermont, and of Blue Hills, Maine, the silver-bearing lead veins of Newburyport, Mass.; most of the segregated gold veins of the Alleghany belt, the lead veins of Rossie, Ellenville, and at other localities farther South; the copper bearing veins of Virginia, North Carolina and Tennessee; the veins carrying argentiferous galena in Central Kentucky, and in Southern Illinois; the silver, copper, and antimony veins of Arkansas; and the lead and zinc deposits of Missouri and the Upper Mississippi.

In these widely separated localities are to be found fissure, segregated and gash veins, and a great diversity of ores, which have been derived, sometimes from the adjacent rocks—as in the segregated veins of the Alleghany belt, and the gash veins of the Mississippi region—and in other cases—where they are contained in true fissure veins—from a foreign source, but all deposited without the aid of superficial igneous rocks, either as contributors of matter or force.

2. In the great mineral belt of the Far West, where volcanic emanations are so abundant, and where they have certainly played an important part in the formation of ore deposits, the great majority of veins are not in immediate contact with trap rocks, and they could not, therefore, have furnished the ores.

A volume might be formed by a list of the cases of this kind, but I can here allude to a few only, most of which I have myself examined, viz.:

(*a.*) The great ore chambers of the San Carlos Mountains in Chihuahua, the largest deposits of ore of which I have any knowledge. These are contained in heavy beds of limestone, which are cut in various places by trap dikes, which, as elsewhere, have undoubtedly furnished the stimulus to chemical action that has resulted in the formation of the ore bodies, but are too remote to have supplied the material.

(*b.*) The silver mines of Santa Eulalia, in Chihuahua, from which during the last century one hundred and twelve millions of dollars were taken, opened on ore deposits situated in Cretaceous limestones like those of San Carlos, and apparently similar ore-filled chambers; an igneous rock caps the hills in the vicinity, but is nowhere in contact or even proximity to the ore bodies. (See Kimball, *Amer. Jour. Sci., March*, 1870.)

(*c.*) The great chambers of Tombstone, and the copper veins of the Globe District, the Copper Queen, etc., in Arizona.

(*d.*) The large bodies of silver ore at Lake Valley, New Mexico; chambers in limestone, like (*c*).

(*e.*) The Black Hawk group of gold mines, the Montezuma, Georgetown, and other silver mines in the granite belt of Colorado.

(*f.*) The great group of veins and chambers in the Bradshaw, Lincoln, Star, and Granite districts of Southern Utah, where we find a host of veins of different character in limestone or granite, with no trap to which the ores can be credited.

(*g.*) The Crismon Mammoth vein of Tintic.

(*h.*) The group of mines opened on the American Fork, on Big and Little Cottonwood, and in Parley's Park, including the Silver Bell, the Emma, the Vallejo, the Prince of Wales, the Kessler, the Bonanza, the Climax, the Piñon, and the Ontario. (The latter, the greatest silver mine now known in the country, lies in quartzite, and the trap is near, but not in contact with the vein.)

(*i.*) In Nevada the ore deposits of Pioche, Tempiute, Tybo, Eureka, White Pine and Cherry Creek, on the east side of the State, with those of Austin, Belmont, and a series too great for enumeration in the central and western portions.

(*j.*) In California, the Bodie, Mariposa, Grass Valley, and other mines.[1]

(*k.*) In Idaho, those of the Poor Man in the Owyhee district, the principal veins of the Wood River region, the Ramshorn at Challis, the Custer and Charles Dickens, at Bonanza City, etc.

In nearly all these localities we may find evidence not only that the ore deposits have not been derived from the

[1] See Remond's Report (*California Geol. Survey Mining Statistics, No.* 1), where seventy-seven mines are enumerated, of which three are said to be in "porphyritic schist," all the others in granite, mica schist, clay slate, etc.

leaching of igneous rocks, but also that they have not come from those of any kind which form the walls of the veins.

The gold-bearing quartz veins of Deadwood are so closely associated with dikes of porphyry, that they may have been considered as illustrations of the potency of trap dikes in producing concentration of metals. But we have conclusive evidence that the gold was there in Archæan times, while the igneous rocks are all of modern, probably of Tertiary date. This proof is furnished by the "Cement mines" of the Potsdam sandstone. This is the beach of the Lower Silurian sea when it washed the shores of an Archæan island, now the Black Hills. The waves that produced this beach beat against cliffs of granite and slate containing quartz veins carrying gold. Fragments of this auriferous quartz, and the gold beaten out of them and concentrated by the waves, were in places buried in the sand beach in such quantity as to form deposits from which a large amount of gold is now being taken. Without this demonstration of the origin and antiquity of the gold, it might very well have been supposed to be derived from the eruptive rock.

Strong arguments against the theory that the leaching of superficial igneous rocks has supplied the materials filling mineral veins, are furnished by the facts observed in the districts where igneous rocks are most prevalent, viz., (1.) *Such districts are proverbially barren of useful minerals;* (2.) *Where these occur the same sheet of rock may contain several systems of veins with different ores and gangues.*

The great lava plain of Snake River, the Pedrigal country of eastern Oregon, Northern California and Mexico are without valuable ore deposits. The same may be said of the Pancake Range and other mountain chains of igneous rock in Nevada, while the adjacent ranges composed of sedimentary rocks are rich in ore deposits of various kinds. A still stronger case is furnished by the Cascade Mountains, which, north of the California line, are composed almost exclusively of erupted material, and yet in all this belt, so far now known, not a single valuable mine has been opened. In contrast with this is the condition of things in California, where the Sierra Nevada is composed of metamorphic rocks which have been shown to be the repositories of vast quantities of gold, silver, and copper. Cases belonging to this category may be found at Rosita and Silver Cliff, where the diversity in the ores of the mines already

enumerated can hardly be reconciled with the theory of a common origin. At Lake City the prevailing porphyry holds the veins of the Ute and Ulay and the Ocean Wave mines which are similar, and the Hotchkiss, the Belle, etc., entirely different.

We have no evidence that any volcanic eruption has drawn its material from zones or magmas especially rich in metals or their ores, and on the contrary, volcanic districts, like those mentioned, and regions, such as the Sandwich Islands, where the greatest eruptions have taken place, are poorest in metalliferous deposits.

All the knowledge we have of the subject justifies the inference that most of the igneous rocks which have been poured out in our Western Territories are but fused conditions of sediments which form the substructure of that country. Over the great mineral belt which lies between the Sierra Nevada and the front range of the Rocky Mountains, and extends not only across the whole breadth of our territory, but far into Mexico, the surface was once underlain by a series of Palæozoic sedimentary strata not less than twenty to thirty thousand feet in thickness; and beneath these, at the sides, and doubtless below, were Archæan rocks, also metamorphosed sediments. Through these the ores of the metals were generally though sparsely distributed. In the convulsions which have in recent times broken up this so long quiet and stable portion of the earth's crust (and which have resulted in depositing in thousands of cracks and cavities the ores we now mine), portions of the old table-land were in places set up at high angles forming mountain chains, and doubtless, extending to the zone of fusion below. Between these blocks of sedimentary rocks oozed up through the lines of fracture quantities of fused material, which also sometimes formed mountain chains; and it is possible and even probable that the rocks composing the volcanic ridges are but phases of the same materials that form the sedimentary chains. There is, therefore, no *a priori* reason why the leaching of one group should furnish more ore than the other; but, as a matter of fact, the unfused sediments are much the richer in ore deposits. This can only be accounted for, in my judgment, by supposing that they have been the receptacles of ore brought from a foreign source; and we can at least conjecture where and how gathered. We can imagine, and we are forced to conclude, that there has been a zone of solution below, where steam and hot water, under great

pressure, have effected the leaching of ore-bearing strata, and a zone of deposition above, where cavities in pre-existent solidified and shattered rocks became the repositories of the deposits made from ascending solutions, when the temperature and pressure were diminished. Where great masses of fused material were poured out, these must have been for a long time too highly heated to become places of deposition; so long indeed that the period of active vein formation may have passed before they reached a degree of solidification and coolness that would permit their becoming receptacles of the products of deposition. On the contrary, the masses of unfused and always relatively cool sedimentary rocks which form the most highly metalliferous mountain ranges (White Pine, Toyabe, etc.) were, throughout the whole period of disturbance, in a condition to become such repositories. Certainly highly heated solutions, forced by an irresistible *vis a tergo* through rocks of any kind down in the heated zone, would be far more effective leaching agents than cold surface water with feeble solvent power, moved only by gravity, percolating slowly through superficial strata.

Richthofen, who first made a study of the Comstock lode, suggested that the mineral impregnation of the vein was the result of a process like that described, viz., the leaching of deep-seated rocks, perhaps the same that enclose the vein above, by highly heated solutions which deposited their load near the surface. On the other hand, Becker supposes the concentration to have been effected by surface waters flowing laterally through the igneous rocks, gathering the precious metals and depositing them in the fissure, as lateral secretion produces the accumulation of ore in the limestone of the lead region. But there are apparently good reasons for preferring the theory of Richthofen: viz., first, The veinstone of the Comstock is chiefly quartz, the natural and common precipitate of *hot* waters, since they are far more powerful solvents of silica than cold. On the contrary, the ores deposited from lateral secretion, as in the Mississippi lead region, at low temperature contain comparatively little silica; second, The great mineral belt to which reference has been made above, is now the region where nearly all the hot springs of the continent are situated. It is, in fact, a region conspicuous for the number of its hot springs, and it is evident that these are the last of the series of thermal phenomena connected with the great volcanic

upheavals and eruptions, of which this region has been the theatre since the beginning of the Tertiary age. The geysers of Yellowstone Park, the hot springs of the Wamchuck district in Oregon, the Steamboat Springs of Nevada, the geysers of California, the hot springs of Salt Lake City, Monroe, etc., in Utah, and the Pagosa in Colorado, are only the most conspicuous among thousands of hot springs which continue in action at the present time. The evidence is also conclusive that the number of hot springs, great as it now is in this region, was once much greater. That these hot springs were capable of producing mineral veins by material brought up in and deposited from their waters, is demonstrated by the phenomena observable at the Steamboat Springs, and which were cited in my former article as affording the best illustration of vein formation.

The temperature of the lower workings of the Comstock vein is now over 150° F., and an enormous quantity of hot water is discharged through the Sutro Tunnel. This water has been heated by coming in contact with hot rocks at a lower level than the present workings of the Comstock lode, and has been driven upward in the same way that the flow of all hot springs is produced. As that flow is continuous, it is evident that the workings of the Comstock have simply opened the conduits of hot springs, which are doing to-day what they have been doing in ages past, but much less actively, *i. e.*, bringing toward the surface the materials they have taken into solution in a more highly heated zone below. Hence it seems much more natural to suppose that the great sheets of ore-bearing quartz now contained in the Comstock fissure were deposited by ascending currents of hot alkaline waters, than by descending currents of those which were cold and neutral. The hot springs are there, though less copious and less hot than formerly, and the natural deposits from hot waters are there. Is it not more rational to suppose with Richthofen that these are related as cause and effect, rather than that cold water has leached the ore and the silica from the walls near the surface? Mr. Becker's preference for the latter hypothesis seems to be due to the discovery of gold and silver in the igneous rocks adjacent to the vein, and yet, except in immediate contact with it, these rocks contain no more of the precious metals than the mere trace which by refined tests may be discovered everywhere. If, as we have supposed, the fissure was

for a long time filled with a hot solution charged with an unusual quantity of the precious metals, nothing would be more natural than that the wall rocks should be to some extent impregnated with them.

It will perhaps illuminate the question to inquire which of the springs and water currents of this region are now making deposits that can be compared with those which filled the Comstock and other veins. No one who has visited that country will hesitate to say the hot and not the cold waters. The immense silicious deposits, carrying the ores of several metals, formed by the geysers of the Yellowstone, the Steamboat Springs, etc., show what the hot waters are capable of doing; but we shall search in vain for any evidence that the cold surface waters have done or can do this kind of work.

At Leadville the case is not so plain, and yet no facts can be cited which really *prove* that the ore deposits have been formed by the leaching of the overlying porphyry, rather than by an outflow of heated mineral solutions along the plane of junction between the porphyry and the limestone. Near this plane the porphyry is often thoroughly decomposed, is somewhat impregnated with ore, and even contains sheets of ore within itself; but remote from the plane of contact with the limestone, it contains little diffused and no concentrated ore. It is scarcely more pervious than the underlying limestones, and why a solution that could penetrate and leach ores from it should be stopped at the upper surface of the blue limestone is not obvious; nor why the plane of junction between the porphyry and the *blue limestone* should be the special place of deposit of the ore.

If the assays of the porphyry reported by Mr. Emmons were accurately made, and they shall be confirmed by the more numerous ones necessary to settle the question, and the estimates he makes of the richness of that rock be corroborated, an unexpected result will be reached, and, as I think, a remarkable and exceptional case of the diffusion of silver and lead through an igneous rock be established.

It is of course possible that the Leadville porphyries are only phases of rocks rich in silver, lead and iron, which underlie this region, and which have been fused and forced to the surface by an ascending mass of deeper seated igneous rock; but even if the argentiferous character of the porphyry shall be proven, it will not be proven that such portions of it as here lie upon the

limestone have furnished the ore by the descending percolation of cold surface waters. Deeper lying masses of this same silver, lead and iron-bearing rock, digested in and leached by *hot* waters and steam under great pressure, would seem to be a more likely source of the ore. If the surface porphyry is as rich in silver as Mr. Emmons reports it to be, it is too rich, for the rock that has furnished so large a quantity of ore as that which formed the ore bodies which I saw in the Little Chief and Highland Chief mines, respectively 90 feet and 162 feet thick, should be poor in silver and iron and lead, and should be rotten from the leaching it had suffered, but except near the ore-bearing contact it is compact and normal.

Such a digested, kaolinized, desilicated rock as we would naturally look for we find in the porphyry *near the contact;* and its condition there, so different from what it is remote from the contact, seems to indicate an exposure to local and decomposing influences; such indeed as a hot chemical solution forced up from below along the plane of contact would furnish.

It is difficult to understand why the upper portions of the porphyry sheet should be so different in character, so solid and homogeneous, with no local concentrations or pockets of ore, if they have been exposed to the same agencies as those which have so changed the under surface.

Accepting all the facts reported by Mr. Emmons, and without questioning the accuracy of any of his observations, or depreciating in any degree the great value of the admirable study he has made of this difficult and interesting field, his conclusion in regard to the source of the ore cannot yet be insisted on as a logical necessity. In the judgment of the writer, the phenomena presented by the Leadville ore deposits can be as well or better accounted for by supposing that the plane of contact between the limestone and porphyry has been the conduit through which heated mineral solutions coming from deep-seated and remote sources have flowed, removing something from both the overlying and underlying strata, and by substitution depositing sulphides of lead, iron, silver, etc., with silica.

The ore deposits of Tybo and Eureka in Nevada, of the Emma, the Cave and the Horn Silver[1] mines in Utah, have much

[1] The Horn Silver ore body lies in a fault-fissure between a foot-wall of limestone and a hanging wall of trachyte, and those who consider the Leadville ores as leachings of the overlying porphyry would probably also regard the ore of the Horn Silver mine as derived from the trachyte hanging wall; but three facts oppose the ac-

in common with those of Leadville, and it is not difficult to establish for all of the former cases a foreign and deep-seated source of the ore. The fact that the Leadville ore bodies are sometimes themselves excavated into chambers, which has been advanced as proof of the falsity of the theory here advocated, has no bearing on the question, as in the process of oxidation of ores which were certainly once sulphides, there has been much change of place as well as character; currents of water have flowed through them which have collected and re-deposited the cerusite in sheets of "hard carbonate" or "sand carbonate," and have elsewhere produced accumulations of kerargyrite, perhaps thousands of years after the deposition of the sulphide ores had ceased and the oxidation had begun. In the leaching and rearrangement of the ore bodies, nothing would be more natural than that accumulations in one place should be attended by the formation of cavities elsewhere.

Another question which suggests itself in reference to the Leadville deposits is this: If the Leadville ore was once a mass of sulphides derived from the overlying porphyry by the percolation of surface waters, why has the deposit ceased? The deposition of galena, blende and pyrite in the Galena lead mines still continues. If the leaching of the Leadville porphyry has not resulted in the formation of alkaline sulphide solutions and the ore has come from the porphyry in the condition of carbonate of lead, chloride of silver, etc., then the nature of the deposition was quite different from that of the similar ones o Tybo, Eureka, Bingham, etc., which are plainly gossans, and indeed is without precedent. But if the process was similar to that in the Galena lead region, and the ores were originally

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ceptance of this view, viz., 1st, the trachyte, except in immediate contact with the ore body, seems to be entirely barren; 2d, the Horn Silver ore "chimney," perhaps fifty feet thick, five hundred feet wide, and of unknown depth, is the only mass of ore yet found in a mile of well-marked fissure; and 3d, the Carbonate mine opened near by in a strong fissure with a bearing at right angles to that of the Horn Silver, and lying entirely within the trachyte, yields ore of a totally different kind. Both are opened to the depth of seven hundred feet with no signs of change or exhaustion. If the ore were derived from the trachyte, it should be at least somewhat alike in the two mines, should be more generally distributed in the Horn Silver fissure, and might be expected to give out at no great depth.

If deposited by solutions coming from deep and different sources, the observed differences in character would be natural; it would accumulate as we find it in the channels of outflow, and would be, as time will probably prove it, perhaps variable in quantity, but indefinitely continuous in depth.

sulphides, their formation should have continued and have been detected in the Leadville mines.

For all these reasons the theory of Mr. Emmons will be felt to need further confirmation before it is universally adopted.

From what has gone before it must not be inferred that lateral secretion is excluded by the writer from the list of agencies which have filled mineral veins, for it is certain that the nature of the deposit made in the fissure has frequently been influenced by the nature of the adjacent wall rock. Numerous cases may be cited where the ores have increased or decreased in quantity and richness, or have otherwise changed character in passing from one formation to another; but even here the proof is generally wanting that the vein materials have been furnished by the wall rocks opposite the places where they are found.

The varying conductivity of the different strata in relation to heat and electricity may have been an important factor. Trap dikes frequently enrich veins where they approach or intersect them, and they have often been the *primum mobile* of vein formation, but chiefly, if not only, by supplying heat, the mainspring of chemical action. The proximity of heated masses of rock has promoted chemical action in the same way as do the Bunsen burners or the sand baths in the laboratory; but no case has yet come under my observation where it was demonstrable that the filling of a fissure vein had been due to secretion from igneous or sedimentary wall rocks.

In the Star District of Southern Utah the country rock is Palæozoic limestone, and it is cut by so great a number and variety of mineral veins that from the Harrisburgh, a central location, a rifle shot would reach ten openings, all on as many distinct and different veins (viz., the Argus, Little Bilk, Clean Sweep, Mountaineer, St. Louis, Xenia, Brant, Kannarrah, Central and Wateree). The nearest trap rock is half a mile or more distant, a columnar dike perhaps fifteen feet in thickness, cutting the limestone vertically. On either side of this dike is a vein from one to three feet in thickness, of white quartz with specks of ore. Where did that quartz come from? From the limestone? But the limestone contains very little silica, and is apparently of normal composition quite up to the vein. From the trap? This is compact, sonorous basalt, apparently unchanged; and that could not have supplied the silica without complete decomposition.

I should rather say from silica-bearing hot waters that flowed up along the sides of the trap, depositing there, as in the numerous and varied veins of the vicinity, mineral matters brought from a zone of solution far below.

To summarize the conclusions reached in this discussion, I may repeat that the results of all recent as well as earlier observations has been to convince me that Richthofen's theory of the filling of the Comstock lode is the true one, and that the example and demonstration of the formation of mineral veins, furnished by the Steamboat Springs is not only satisfactory, but typical.

WATER ANALYSIS.

By Prof. H. B. CORNWALL, A.M., E.M.

THE purpose of this paper is to describe a few variations in some of the well-known operations of water analysis, which have, for the most part, for several years been employed in the laboratory at Princeton with advantage, in conducting several hundred analyses, principally of well waters. No original methods will be proposed, and some of the variations have already been published, but it is believed that they may with profit be brought to the notice of some of the readers of the QUARTERLY.

Nessler Reagent.—This is prepared according to the directions in Wanklyn's *Water Analysis.* After dissolving the potassium iodide and corrosive sublimate by boiling with water, as he directs, the solution is allowed to cool before adding any of the cold, saturated solution of corrosive sublimate, which he directs to be added; while, after the addition of the caustic potash and making the solution up to a litre, corrosive sublimate solution, cold and saturated, is added *until a slight, permanent turbidity is produced,* in order to render the reagent sensitive and durable. Wanklyn simply directs that, at this last stage, "a little more" of the corrosive sublimate be added. Prepared with the above precautions, the Nessler reagent has always been found very sensitive, and it will not change in a very long time, while before they were adopted it was often found not to be sensitive at the end of a week or two.

Standard Solution of Ammonia.—Both the stronger and the

dilute solutions are prepared according to Wanklyn. Leeds (*Proceed. Am. Chem. Soc.*, Vol. 2, Dec. 5, 1878) found that a solution of ammonium chloride containing 0.7867 grm. of the salt to the litre, lost nearly one-twelfth of its ammonia in about a year. The writer found that a solution of 3.15 grm. to the litre had lost less than one-sixtieth of its ammonia in about four years (*Amer. Chem. Jour.*, Vol. 2, p. 45). A dilute solution, 0.0315 grm. to the litre, which had been in constant use for several months by students, although it seemed to have been used with reasonable care, had lost nearly one-eighth of its ammonia, having stood in diffused daylight for the greater part of the time. Leeds states that his altered solution showed a filamentous, apparently vegetable growth, and a considerable white sediment was visible in the dilute solution which the writer observed, while his stronger and little changed solution showed no sediment at all. It is clear that ammonium chloride solutions, if frequently opened, and especially if dilute, may become very seriously altered, and they should be tested from time to time, particularly if any sediment is formed. At the same time, it is true that such solutions do not always change; for another of the stronger solutions used by the writer at intervals for three years to make up dilute solutions, showed no loss of ammonia whatever.

Alkaline Potassium Permanganate Solution.—This, for the albuminoid ammonium determination, is made according to Wanklyn, and from common white stick potash. The writer has heard the statement that, although such a solution may yield no ammonia when freshly made, it may do so after being kept for some time and again boiled. Whether this can ever happen the writer has had no occasion to observe; but such a result is readily avoided by boiling the necessary quantity of the solution for a few minutes before using it, and the writer always does this, since, thereby, the solution may be also added to the hot water in the retort without cooling the latter unnecessarily. The bumping of the water after the addition of the permanganate is best prevented by the use of a couple of bits of freshly ignited pumice-stone, which secures a better effect than fragments of clay pipe, or platinum foil or wire.

Nesslerizing.—This is performed by a method the principle of which was first proposed in England by Dr. Parsons. The 50 c.c. of the distillate in which the ammonia is to be determined is first treated with the necessary 2 c.c. of Nessler

reagent, and as soon as the half minute or so necessary for it to acquire approximately its full depth of color has passed, a comparison solution is made up by putting into another Nesslerizing cylinder a quantity of Wanklyn's "dilute ammonia solution," judged to be a little more than sufficient to produce an equal depth of color. The second cylinder is filled to the 50 c.c. mark with ammonia-free water, and then also treated with 2 c.c. of Nessler reagent. In about five minutes the color of the two liquids is compared. It will usually happen that the comparison solution is the darker. If so, this is emptied into a Gay Lussac or a glass-stoppered burette, its height in this burette is noted, and then the comparison solution is run back into the empty cylinder until a sufficient quantity is in the latter to produce a depth of color, when both are viewed from above, equal to that of the whole 52 c.c. in the cylinder containing the water whose ammonia is to be determined. The quantity run out is then noted from the burette, and, the two cylinders being of equal bore, a simple rule of three calculation gives the desired result. Should the comparison water have been made up with too little ammonia chloride solution, as sometimes happens, the operation is conducted as above, excepting that the water whose ammonia is to be estimated, being in this case the darker liquid, is poured into the burette. As will be seen from figures previously given by the writer in describing this process (*Amer. Chemist*, Vol. VI., p. 210), very close results are readily obtained. Where the greatest accuracy is not required, or when no burette is at hand, it suffices to pour out some of the water from the cylinder whose contents are darker, until equal depths of color are obtained in both cylinders, and then to measure the height of the columns of liquid in each cylinder with a sufficiently fine scale, such as a millimeter scale, the calculation being made as before.

This method is very much to be recommended, not only for its convenience in avoiding the use of more than 50 c.c. of ammonia-free water for each distillate to be Nesslerized, but also because it insures the highest degree of accuracy. This last result is especially due to the fact that both solutions have been made up for essentially the same length of time, and this is important because Nesslerized solutions increase somewhat in depth of color for quite a time.

The writer uses flat-bottomed Nesslerizing cylinders of thin white glass, about 170 mm. high and 25 mm. inside diame-

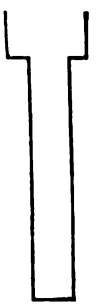
ter. When observing the color of the solutions these cylinders are held vertically over, but not quite in contact with, a piece of unglazed white paper, supported at an angle of about 35° with the horizon, the observer's eyes being vertically over the cylinders.

Oxygen Consumed by Organic Matter.—This is ascertained by means of standard potassium permanganate solution added to the water to be tested after the latter has been slightly acidified with sulphuric acid, according to the directions in Kubel-Tiemann's *Untersuchung von Wasser*, which method has been found invariably to require the use of more permanganate than Tidy's, in tests made in this laboratory. Kubel-Tiemann's method consists in boiling the water with the permanganate for five minutes, and determining the excess of permanganate by means of standard oxalic acid solution. In view of Mallett's testimony (*Chem. News*, Aug. 18, 1882) that, in some cases, the effect of the permanganate at a boiling temperature for five minutes may be less than by Tidy's method, presumably on account of the escape of some volatile and oxidizable compound, it might be well to combine the two methods, by allowing the permanganate first to act at ordinary temperatures and then at the boiling temperature.

In regard to Tidy's method, reference may here be made to McCay's excellent proposal (*Chem. News*, April 27, 1883) to employ dilute ferrous-ammonium sulphate solution in determining the excess of permanganate, rather than the solutions of sodium hyposulphite, potassium iodide, and starch employed by Tidy.

Nitrogen as Nitrates and Nitrites.—Crum's method, as described by Frankland (*Water Analysis*), is employed, and it is only necessary here to describe the mercury trough used in connection with the decomposing tube, which serves also as a nitrometer. The nitrometer is similar to that described by Frankland, but is graduated in opposite directions into fifths of a cubic centimeter both above and below the stop-cock, so that the quantities of concentrated water to be tested, and of sulphuric acid to be added may be conveniently measured. The use of the mercury trough in connection with this nitrometer has been found more convenient than Lunge's nitrometer (*Sulphuric Acid and Alkali*, Vol. I.) for the estimation of such small amounts of nitric acid, although it requires a quantity of mercury which might not always be at hand in private laboratories.

The trough is made of stout glass, and consists of a cylinder, closed below and widening at the top into a cup with straight sides, as shown in the figure. The diameter of the narrow, deep part is about one-third greater than that of the nitrometer, and the depth of this part is 5 millimeters less than the length of the nitrometer from the middle of the axis of the stop-cock to the end of the longer part. The height of the wider cup-like portion of the trough is about 60 millimeters, and its diameter such that the stop-cock of the nitrometer does not quite touch the side of the cup when the longer tube of the nitrometer is introduced nearly to the bottom of the deep cylinder. The trough is filled when in use with so much mercury that the stop-cock of the nitrometer can be readily submerged in it so as to fill the decomposing tube, and partly to fill the cup above the stop-cock.



The concentrated water to be tested is introduced through the little graduated cup on the nitrometer, and drawn into the lower tube of the nitrometer by raising the instrument a little in the mercury and opening the stop-cock. If any air is drawn in, this is readily expelled by again sinking the instrument in the mercury. A drop or two of the sulphuric acid is next introduced through the perforated stop-cock, and if any considerable evolution of carbon dioxide ensues this gas is also expelled in the same way. Then the whole quantity of sulphuric acid necessary to effect the decomposition of the nitric acid is introduced, the cock closed, the nitrometer nearly drawn out of the mercury and closed at the lower end with the thumb, after which the acidified water and mercury are thoroughly agitated together as Franklin directs. After the nitrogen dioxide has nearly all been given off, that is, after three or four minutes of vigorous shaking, the tube is replaced in the trough, and the shaking continued as long as necessary by rapidly moving the tube up and down in the deep trough. It is at this stage of the operation that the trough is especially convenient, because when the decomposing tube is closed by the thumb during the whole time necessary to secure the evolution of the nitrogen dioxide the hand becomes very tired. When the evolution of the gas has ceased, the apparatus is left at rest until the gas assumes the temperature of the room, or this result is hastened by submerging the lower part of the tube in the mercury and

shaking its contents gently. To read the volume of the cool gas the nitrometer is sunk in the trough until the mercury stands at the same level inside and outside of the decomposing tube, after which the necessary allowance for the column of acid liquid is made by sinking the nitrometer into the mercury trough to a distance equal to one-seventh the height of the acid column (Lunge, *op. cit.*, p. 87). Exclusive of the cost of the mercury, the apparatus is inexpensive and very easily handled.

In making the correction for atmospheric pressure, temperature and tension of aqueous vapor, the writer follows Gibbs's method (Fresenius's *Quantitative Chemical Analysis*, Amer. ed., 1876).

It is well, but not indispensably necessary, to absorb the nitrogen dioxide, after reading the volume of the gas, by passing a warm and strong solution of ferrous sulphate into the nitrometer and to deduct the volume of unabsorbed gas, although this will always be very small, unless air has been accidentally admitted. It is a curious fact that when the volume of the nitrogen dioxide amounts to a few cubic centimeters, scarcely an appreciable permanent alteration is made by drawing a little air into the nitrometer, because the uncombined nitrogen of the air nearly equals in volume the absorbed gas thus formed from the nitrogen dioxide. Naturally an error would result if the nitrogen dioxide were afterward to be entirely absorbed by ferrous sulphate solution and the volume of the remaining nitrogen deducted.

While not absolutely necessary, it will be found convenient, if the chlorine as chlorides exceeds five or six parts per 100,000, to previously separate it as silver chloride, by addition of nearly enough saturated, cold aqueous solution of silver sulphate to precipitate all of the chlorine; the quantity of the latter in the water having been previously determined.

Crum's method for determining nitric acid is as accurate as is needed for water analysis, and is very convenient. It may be objected to, on the ground that the evaporation of water in presence of organic matter can give rise to the formation of nitrites. To this it may be answered, that if the evaporation is rapidly conducted, and on not too much water (the writer uses 200 c.c.), the quantity of nitrites will be altogether unimportant, and often none whatever has been thus found to result from evaporations of various impure waters. A check on

the error could readily be made by determining nitrous acid before and after evaporation by Griess's method.

Crum's method will show the nitrogen in potassium nitrate to within two per cent. of the quantity present, if about 5 c.c. of nitrogen dioxide are obtained, even by the use of the simple nitrometer above described.

Nitrites.—No quantitative test is made for nitrous acid, but simply a qualitative test under fixed conditions as to quantity of water taken, strength of solutions of potassium iodide, sulphuric acid and starch, sufficient to admit of a rough estimate of the quantity present.

General Remarks.—Experiments are now in progress at this laboratory to determine whether any opinion as to the probably more or less nitrogenous nature of organic matter in water can be formed from a comparison of the observed amounts of "albuminoid ammonia" and "oxygen consumed by organic matter." Tests made on such characteristic liquids as beef tea and infusion of soft and fresh wood chips gave decisive results, but the investigation has not yet been carried far enough to show whether the approximate proportion of organic carbon and nitrogen can be determined in this way, or whether any clue to the source of the organic matter in ordinary waters can be so obtained.

Before closing this paper, attention is called to the recent article by Darton, which originally appeared in the *Jour. Amer. Chem. Soc.*, and has been reproduced in the *Chemical News*, Feb. 8th, 1884, giving some very interesting results of experiments made by him on the volatile nitrogenous organic matter which Remsen (*Amer. Chem. Jour.*), and later, Marsh (*Amer. Chem. Jour.*), have shown to exist in many waters. Darton concentrated the distillate from various well waters, and tested the residue by injecting it under the skin of rabbits, producing in most cases either death or very serious disturbances in the animals. These marked effects were obtained from waters which had been shown to contain much volatile nitrogenous matter.

DECOMPOSITION AND ANALYSIS OF SLAGS.

BY MALVERN W. ILES, PH.D.

SEVERAL years ago, in the columns of the *Engineering and Mining Journal* (Vol. 31, p. 58), I described a method for the decomposition of slags, for analytical purposes. This method, briefly stated, was to fuse the finely powdered slag with caustic potash in a silver crucible.

Since then I have found the method to be applicable to a large class of ores and furnace products; and that for estimating sulphur in slags and minerals by such fusions, and the subsequent use of bromine water, the method is also capable of wide application.

The chief objection to this method, arises from the fact that in the fusion the silver crucible is more or less attacked by the caustic alkali, and that inasmuch as argentic chloride is quite soluble in a hot solution of potassium chloride, the silver will give trouble in the subsequent analytical determinations. To obviate this difficulty, W. Bettel advocates[1] the use of gold lined or plated platinum crucibles for such fusions with potassium hydrate.

This is a most valuable suggestion, and the method as originally detailed,[2] together with this modification, becomes applicable to the decomposition of nearly all silicates, and to the estimation of sulphur in nearly all inorganic as well as organic bodies.

I now find it is not necessary to make a fusion of any slag I have ever seen produced in connection with the lead-silver industry.

About two years ago, I learned from Mr. Hermann Schlapp, that he was using a "*glassy*" sample for analytical purposes, and that the slag he produced was decomposed with hydrochloric acid. I found to my surprise that if the hot flowing slag is allowed to run upon an iron rod, and while the slag is still hot, the rod is plunged into cold water, not only the physical, but the chemical properties of the slag are so changed that upon drying the sample, it becomes completely decomposed by concentrated hydrochloric acid. The slag samples so taken are

[1] *Chemical News*, 43, 94; see Note *Am. Chem. Jour.*, 1881. Vol. 4. No. 1. p. 57.

[2] *Scientific American Supplement*, No. 126, June 1, 1878.

also readily attacked by most of the other inorganic acids, and are more or less decomposed by many of the organic acids.

Tartaric acid partially decomposes the slag, at a boiling temperature, giving rise to formation of much gelatinous silica.

Acetic acid very slightly attacks the slag on boiling and using strong acid (sp. gr. 1.055); and by filtration and the addition of ammonia, some iron is precipitated, and the filtrate from the iron shows a small amount of lime.

A strong solution of sodium hydrate when boiled with the slag gives an intense green solution of sodium manganate (when manganese is present). Upon adding boiling water to this green solution, the manganese is precipitated.

Bromine water added to the finely divided slag, attacks it very vigorously, giving hydrated oxides of iron and manganese; if now a few drops of strong sulphuric acid be added, the iron and manganese are of course readily dissolved, leaving practically pure hydrated silicic acid. Inasmuch as the silicic acid so obtained does not filter well, no practical use of this very curious reaction can be made in the laboratory.

The above mentioned simple tests very plainly indicate, that by rapid cooling the slag is markedly changed in its chemical properties. If one closely examines a pot of newly drawn slag, there will be observed on the outer edges a very fine shell or plate of glassy looking slag, varying in thickness from $\frac{1}{8}$ to $\frac{1}{32}$ of an inch—and also, where the slag has come in contact with the upper rim of the pot, there will be an appearance of a glassy or silicious slag; this will be noted even when the slags are quite basic. All of these glassy surfaces or portions of the slag are generally completely soluble in hydrochloric acid, whilst if we allow the slag to cool *slowly*, alkaline fusions, or treatment with hydrofluoric acid, or heating with some strong acid in sealed glass tubes, is necessary to effect decomposition.

My method of taking the laboratory samples at these works, is to use an ordinary tapping bar, and after there begins to form a very thin crust upon the newly drawn pot of slag, to throw aside this crust with one end of the bar, and immerse the other end into the pot of slag about four inches; then very quickly withdraw and plunge into a bucket of water. This mode of taking the sample is applicable for both the assay and laboratory determinations; more care, however is used in

taking the laboratory sample, in order to secure a thin crust or shell, and also to lose no time in plunging into water.

In cases where much matte is formed, I think the method just detailed is the fairest by which the sample can be taken; that is, when due care is taken to save and re-work the matte (or lead regulus). I have several times had the laboratory samples accidentally contaminated with plates of iron rust, scaling off from the iron pans in drying the sample; therefore, I have procured porcelain or "granite" lined cups (shaped like the ordinary tin cups), and find they are admirably adapted for this purpose.

In order that my mode of procedure may be clearly understood, I will state very briefly the routine operations, viz.:—allow the flowing slag to run upon the end of a steel bar, or dip the bar into the newly drawn pot of slag; plunge into water, dry the sample upon the slag pot, powder and pass through an 80-mesh sieve; now grind a small portion in an agate mortar for two or three minutes, and then weigh out the desired amount for analysis. It is generally unnecessary even to powder in an agate mortar, for the estimation of silica, iron and lime; and only in making complete analysis of the slag, or where unusual care is required, is this operation performed.

After using the above method for over two years, I find that all slags containing an amount of silica varying from 30 to 42 per cent. are entirely decomposed by hydrochloric acid.

I am led to the belief that the slags produced by the iron smelting industry will also be soluble in strong hydrochloric acid. I will be glad to hear from some of the iron smelters upon this point.

One of the main distinguishing features of a singulo-silicate slag in contradistinction from the bi-silicate (also the so-called "mixed" or sesqui-silicate), is that the singulo-silicate is soluble (generally) in strong hydrochloric acid, whilst the bi-silicate is only imperfectly soluble. I am inclined to the belief that almost *all* slags are soluble in concentrated hydrochloric acid, if we use the precaution to take a very thin crust or scale upon a steel bar, and immediately plunge into cold water. I do not find that by taking the samples in this manner, the chemical composition is materially changed, certainly, it is not perceptible, so far as the silica, iron, lime and manganese are concerned; and for practical working of the furnaces, these are

the main ingredients which the metallurgist desires to know. It would be reasonable to suppose that part of the sulphur, and perhaps a minute trace of arsenic, antimony and phosphorus would be eliminated in combination with hydrogen.

Before leaving this part of the subject, I will state, that I see no reason why many slags could not be made a source for a number of inorganic salts; such as iron, lime, manganese, vanadium, etc.; perhaps a portion of the lead and silver could be saved; also the (gelatinous) silica. Nor is it unreasonable, in view of the above facts, to utilize even basic slags for the manufacture of building and paving brick.

Analysis of Slags.

After taking the slag sample, as previously indicated, weigh out from ½ to 1 grm., transfer to a covered casserole, add from the wash bottle a few drops of water, stir well, add concentrated hydrochloric acid, again stir, and digest over a free flame for a few minutes. The addition of water and the stirring prevents the slag from clotting or caking upon the bottom of the vessel.

Now add a few drops of nitric acid, both to insure the oxidation of the iron and also to decompose a few specks of lead sulphide which are apt to form during the first addition of hydrochloric acid, and rise upon the sides of the vessel. Evaporate to dryness upon the water-bath; this is not a long operation if the analyst will use a minimum quantity of hydrochloric acid (say 6 to 8 c.c.). After the evaporation is completed, add a few drops of water, just sufficient to moisten the mass, and evaporate the second time. Now add a slight excess of concentrated hydrochloric acid, warm, dilute and filter, washing the silicic acid with boiling water, and drop a small amount of hydrochloric acid around the edges of the paper; wash again with water. The moist residue, with filter paper, is transferred directly to either a porcelain or platinum crucible, placed in an ordinary scorification cup, and dried before the assay muffle until the paper begins to carbonize. It is then placed in the muffle for about five minutes, removed, and allowed to cool, and the silica then weighed. The silica will be found perfectly white, not even tinted with iron, and the determination is as accurate as if a fusion had been performed.

For the determination of the iron it is advisable to take a

second portion of ½ grm., boil with hydrochloric acid to complete decomposition in a casserole; then dilute with water and add a small piece of unamalgamated zinc, directly into the covered vessel. After a few minutes the cover is removed, washed, and the contents of the casserole are cautiously transferred by decantation to a *large* beaker, and diluted up to 500 c.c.; now add rather a large amount of concentrated sulphuric acid (say 25 c.c.), and titrate the iron with a standard solution of potassium permanganate.

It will be noted that it is entirely unnecessary to remove the silica in order to determine the iron, and furthermore, *time* is saved by reducing the iron by unamalgated zinc directly in the vessel in which the decomposition of the slag is effected.

While the above mode of procedure may seem somewhat crude, yet it can be shown that all of the precautions are taken to secure accuracy in estimating iron in a hydrochloric acid solution. Zimmermann proved that the addition of manganese sulphate allowed an accurate estimation of iron by potassium permanganate in a hydrochloric acid solution; and quite recently J. Krutzwig and A. Cocheteux showed[1] that manganese sulphate might be omitted by taking the precaution to use: 1. as little hydrochloric acid as possible for the solution of iron, 2. to reduce with zinc in a hydrochloric acid solution, 3. to use twice as much sulphuric as hydrochloric acid, 4. to dilute largely and use a dilute solution of permanganate of potassium.

For commercial work, a solution of permanganate about $\frac{1}{10}$ normal (6.5 grms. per liter), is recommended.

For the estimation of lime, two methods are used according to the accuracy to be attained. If for quick work, we wish to ascertain the percentage of lime, we use the filtrate from the silica as follows: heat this filtrate, add ammonia to slight alkaline reaction; then add a saturated solution of oxalic acid to dissolve the iron; boil for a few minutes, allow to stand 25 minutes, filter hot, wash well, and transfer to a casserole; add some hot water, and sufficient hydrochloric acid to dissolve the calcium oxalate, filter, and dilute with cold water. Now add rather a large amount of sulphuric acid; heat to boiling and titrate with a solution of permanganate.

[1] *Berichte der deutschen chemischen Gesellschaft*, 16,—1534.—See note in *Am. Chem. Jour.*, Vol. 5, No. 6, p. 459.

If a greater degree of accuracy is desired, the iron and alumina are removed as basic acetates, then manganese is separated by bromine water, the zinc removed by sulphureted hydrogen and the filtrate treated according to the usual method. Some manganese will invariably pass into the filtrate, when the iron is precipitated by ammonia, and will come down with the lime, introducing thereby an error to the extent of its presence. Where, however, the amount of manganese is small in comparison to the amount of iron, we can often use the first mentioned method with a great saving of time. For the manganese determination, take 1 to 2 grms. of the finely powdered slag, according to the amount of manganese present, and treat in a casserole with concentrated hydrochloric acid, with the addition of a small amount of nitric acid in order to convert all the iron into the ferric form. Now boil, and add sulphuric acid, gradually replacing all of the nitric and hydrochloric acids; the success of the operation depends upon the entire removal of the hydrochloric acid. Dilute to about 150 c.c. and boil; add an emulsion of zinc oxide in large excess, by which the iron is precipitated as ferric hydrate; filter off the silica, oxides of zinc and iron, and dilute up to 500 c.c. Some writers recommend before the addition of zinc oxide, to neutralize with sodium carbonate and then clear up the solution with a few drops of nitric acid; this in practice we have found to be unnecessary.

Draw off from the diluted liquid, after thorough mixing, an aliquot part, say 100 c.c., transfer to a casserole, heat to boiling, and titrate with frequent stirring, with a normal solution of potassium permanganate, until the first rose tint is obtained. Calculate the per cent. of iron corresponding to the permanganate used, and multiply this per cent. found by 0.2946 = per cent. Mn.[1]

The manganese scheme as above stated is highly recommended, both for rapidity and accuracy; in fact there is no known method which we think will compare with it for technical and scientific work.

Occasionally arsenic determinations are required upon the slags; for this determination the writer thinks there is no known method which will compare with that of Prof. Pearce, as detailed by Mr O. J. Frost in the columns of the *Engineering*

[1] See original article, *Zeit. für Anal. Chem.* 20th year, page 271; also recent articles by Williams, Stone and others in the *Trans. Amer. Inst. Min. Eng.*

and Mining Journal (*see vol.* 35, *p.* 256). The method is a general one, and is applicable to ores, furnace products, etc.

The sulphur is determined by the "Fahlberg-Iles" method as follows:

Fuse from 1 to 2 grms. finely powdered slag in a silver or platinum gold-lined crucible, with 25 grms. potassium hydrate for 20 minutes, cool, dissolve in water, filter off hydrated oxide of iron, etc.; now add 30 c.c. bromine water, and then concentrated hydrochloric acid to acid reaction; boil off excess of bromine, filter if necessary, add barium chloride, and proceed as usual for the treatment of barium sulphate.

Mr. Walter T. Page, chemist to these works, has kindly favored me with the scheme for zinc determinations, which he is using with good success. I will take this opportunity to acknowledge my indebtedness to Mr. Page for much valuable aid, throughout the entire preparation of this paper.

ZINC SCHEME.

Treat 1 grm. of substance with 10 c.c. HCl + 5 grms. HNO_3 + 4 grms. H_2SO_4; acids concentrated and added in the above given order. Digest over a free flame to perfect decomposition, until thick fumes of H_2SO_4 appear; cool, dilute to 150 c.c., and filter; wash with hot water—now add 2 c.c. HCl and pass a rapid stream of H_2S to saturation; filter, and wash; boil filtrate, and oxidize with $KClO_3$. Precipitate iron and alumina with ammonia, using large excess; filter and wash. (If the percentage of zinc is large, it is best to redissolve and re-precipitate, and combine filtrates.)

Add now HCl to decided acid reaction. Transfer to ½ litre flask—fill to mark, mix thoroughly and draw off an aliquot part. Titrate this directly with a standard solution of potassium ferrocyanide,[1] using uranium acetate as the indicator. The ferrocyanide solution is made up with about 43 grms. K_4FeCy_6 per litre. Ammonium chloride interferes slightly with the accurate determination of zinc by this method; therefore we use the same amount of reagents, and correct for the ammonium chloride in each case. Manganese, nickel and cobalt interfere—hence they are to be removed before titration.

The results of the fire assays for lead and silver are generally all that is necessary; if, however, a complete analysis of

[1] See original paper by Dr. Fahlberg, *Zeit. Anal. Chem.*, 1874-379.

slags is to be made, the lead is estimated as a sulphate in the usual manner.

Some writers on metallurgy, and certain metallurgists, I am inclined to think, seem to over-estimate the importance of using wet methods for lead and silver. Dr. Percy is inclined to the belief[1] "that the dry method of assaying must always be resorted to as the only direct, accurate, and practical method" for commercial determinations of both lead and silver. The writer, after having used a number of proposed methods to facilitate the above determinations, has come to the same conclusion. There are, however, two wet methods that deserve special mention; one of these is the method used at Bleiberg,[2] where lead sulphate is digested for one hour with sodium carbonate, the resulting lead carbonate dissolved in acetic or nitric acid, and the lead precipitated from this solution as a sulphate, in which form it is weighed.

The other method is the one proposed by A. E. Haswell,[3] and was subsequently altered by H. v. Jupner.[4] This method, very briefly stated, is:

Use a nitric acid solution of the substance to be determined, add an emulsion of zinc oxide, titrate in the cold to slight rose tint with a deci-normal solution of permanganate, warm, and add a few drops of permanganate until the second tint is observed.

My experience with the foregoing method is, that the other subtances mentioned by von Jupner, which may replace the zinc oxide, as potassium and ammonium hydrates, sodium and ammonium carbonates, and also quicklime, do not give entire satisfaction, while, by the use of zinc oxide, the results are exceedingly good. I, therefore, have come to the conclusion, that if one can only succeed in getting *all* the lead into solution as a nitrate, the method is an accurate one. Inasmuch as many lead ores contain lead sulphate and lead in other forms which are liable to tenaciously resist the ordinary solvents, the method should only be used with great discretion. In cases where lead sulphate is present, perhaps it could be advantageously removed from the silicious residue by digestion with sodium carbonate, or the lead sulphate could be easily

[1] *Percy's Metallurgy of Lead*, page 120.
[2] *Percy's Metallurgy of Lead*, page 270.
[3] *Dingler's Polytech. Jour.*, Bd., 241, p. 393.
[4] *Oesterreichische Zeit. für Berg- und Hutt.* for 1881, No. 51.

decomposed by metallic zinc in a hydrochloric acid solution.[1] The difficulty of obtaining zinc which is free from lead would militate against this mode of procedure. The volumetric estimation of lead by potassium dichromate is not used at any of the western metallurgical works, and, I think, for good reasons, as the method is valueless.

Volhard's method for the volumetric estimation of silver by ammonium sulphocyanide is a most excellent one, where it can be applied.

These are all of the ingredients the chemist will ordinarily be called upon to determine in connection with the lead-silver smelting industry. Slags, however, may and generally do contain any one or several of the following elements: Ba, Cu, Ni, Co, V, Sb, P, K, and Na. If any of these are to be determined, the methods as given by Fresenius, Rose, Sutton, Cairns or Hart are followed.

In conclusion, I will state that the above methods we also use daily for ores and furnace products, and we regard them for the performance of our work as invaluable.

Omaha & Grant Smelting and Refining Co., March, 1884.

GOLD CHLORINATION IN CALIFORNIA.

By F. D. BROWNING, E.M.

GRASS VALLEY, California, has become famous as a gold quartz mining district. The country is composed of alternate belts of slate and granite. It is intersected in every direction by quartz veins, some of which cut across both the belts of slate and of granite, while others follow for some distance the dividing plane between the two formations and then strike off through either of them. A part of the gold found in these veins is free, and a part is contained in sulphurets This is true of all the mines in the district, but the percentage of free gold and the character of the sulphurets vary greatly in different veins. The Idaho Mine, situated in the city of Grass Valley, is a good example of those carrying a large percentage of the gold in a free state; while the Providence Mine in Nevada City, four miles distant, exhibits the other extreme of heavily sulphureted ores. All the ores are worked by the

[1] See article in SCHOOL OF MINES QUARTERLY for March, 1882, by the writer.

same process, which is briefly as follows: The ore is stamped wet; the free gold is amalgamated in the stamp battery and on plates set below it; the tailings flowing off the plates are concentrated; and the concentrates are treated by chlorination. The system of stamping is quite uniform throughout the district. The methods employed for concentrating the tailings, however, are various, including the use of different forms of buddles, settling tanks, blanket sluices, etc., but unquestionably the best system is that in which Frue vanners are employed.

The Providence mill and chlorination works illustrate the best practice in the district and, so far as I know, in the country. It is proposed, therefore, in the following article, to give a full description of them.[1]

THE ORE AND ITS TREATMENT.

Character of the Ore.—The Providence gold ore is a heavily sulphureted quartz, which is hard and generally solid, though sometimes intersected by seams of chlorite. About seven per cent. of the total weight of ore are sulphurets, consisting mainly of pyrites with smaller quantities of galena, chalcopyrite, arsenopyrite, and a very little zinc blende. The proportion of free gold to the total amount in the ore was not ascertained.

Milling.—Waste rock is separated from the ore in the mine, and is either filled into old stopes or sent to the surface during the night. All the ore is hoisted without sorting, and is sent over a tramway directly into a rock-house in the top of the mill. There it is dumped upon grizzlies through which the fine dirt falls into an ore bin, while the coarse rock passes over them and is delivered to rock breakers. In the coarse ore there are some pieces of nearly pure sulphurets, which are thrown to one side and treated separately; the balance of the coarse stuff is fed into the rock breakers and falls from these directly into the same bin that holds the fine dirt. From this bin all the ore passes down chutes to automatic feeders which deliver it to the stamp batteries. The ore is reduced in the batteries till it passes through a No. 5 punched screen; then it runs as a slime over silver-plated copper plates to Frue concentrators.

[1] I take this occasion to express my thanks to the Messrs. Walrath and to Mr. Hunter, owners and managers of this property, for the privilege of studying their operations and for the data furnished by them.

The stamps are run with a 7-inch drop, and at a speed of 96 drops per minute. The screens are equivalent in fineness to a 30 to 40 mesh sieve, according to the length of time that they may have been in use. The stamping, therefore, is coarse, and especially so because of a low discharge and a high speed; but the free gold is effectually released and is caught in the battery and on the plates, while that contained in the sulphurets is recovered from the concentrates.

The amalgamating plates are inclined $1\frac{3}{4}$ inches in 1 foot. This rather steep pitch is employed in order to keep the plates clean and yet avoid the use of much water which would flood the concentrators. Water is used in the batteries in quantities only barely sufficient to keep the plates clean at this inclination; if there is an occasional banking up of sulphurets on the plates the latter are readily cleansed with a hose. On the washing field of each Frue vanner just enough clear water is used to prevent the gangue from being carried with the concentrate over the head of the machine. Great care is taken to have the concentrators perfectly level, and their lateral motion properly adjusted, to prevent the sand from banking on either side of the traveling belt.

The tailings from the concentrators, being practically barren,[1] are run into the river; the concentrates, which prove remarkably clean,[2] are spread on the floor of an adjoining room to dry.

When the coarse pieces of sulphurets, picked from the ore in the rock-house, have accumulated in sufficient quantity, they are put through a battery separately, and from the battery plates the rich sulphuret pulp is run directly into settling tanks, from which it is afterward shoveled, and mixed with the concentrates on the floor of the drying room.

The dried sulphurets[3] are taken to the Chlorination Works, where they are roasted, chlorinated, and leached.

Roasting.—The roasting is performed in a three story furnace of elliptical plan, the third floor being the top of the furnace and not covered.

The sulphurets (henceforth called *ore* for convenience) are dumped on a brick floor level with the top of the furnace. After all the lumps are broken by working the ore over with a

[1] Stated to contain but $\frac{1}{10}$ of one per cent. of sulphurets.

[2] Containing as a maximum 10% of sand.

[3] The value of these is said to be $120 in gold and $12 in silver per ton.

shovel, a charge is spread over the top of the furnace, four or five tons of ore being kept continually drying and heating, but no stirring is required. Thence the thoroughly dried and heated ore passes to the middle or second hearth, in which likewise five tons are kept. Here the ore is thoroughly stirred over at intervals of ten or fifteen minutes, and a great part of the sulphur is burned off, the temperature being sufficient to keep the charge at a medium red heat. The ore is next drawn to the lowest hearth—two tons being moved every twelve hours, or, if it be necessary to force the work, one and a half tons every eight hours. As often as this charge is drawn to the lower hearth an equal quantity is drawn down on to the second hearth, and the same amount is added on top of the furnace, the ore being so manipulated that the portion which has been longest on each hearth is drawn to the one next below. After the charge has been in the last hearth four hours the fire is allowed to go down a little, and 1% of salt is spread evenly over the ore. The fire is then raised to the regular temperature, keeping the ore at a bright red heat, and this is maintained until the roasting is complete—or for four hours when treating a charge of a ton and a half, and six hours for one of two tons. On the lowest hearth the ore is well stirred every ten or fifteen minutes till within half an hour of the time for drawing, when it is raked into a pile and so left until discharged.

One man tends the whole furnace, dividing most of his time between the middle and the lowest hearths, where all the stirring is done. It is very essential that the ore be *perfectly* roasted; any sulphur remaining in it can be detected by the smell when hot.

By this process of roasting the following effects are produced in the charge: Any arsenic or antimony present is oxidized and volatilized; the sulphides of iron, copper, zinc, and silver pass through stages of oxidation; and by the addition of salt most of the silver is converted into a chloride, and some chloride of copper is formed, while the balance of the base metals is completely oxidized. The gold is left in a free metallic state.

By conducting the process just as above described, except that the ore was discharged in one or two hours after adding the salt instead of in four to six hours, it was found that more silver was saved, but less of the gold. The reason for this is not far to seek. The more complete the roasting the more

gold can be chlorinated, while some silver is carried off in form of a chloride by chloride of copper formed during the last stage of roasting, and is lost. The metallic gold is not thus carried off, and hence it is not lost by long continued roasting at a high temperature.[1]

The roasted ore is left in a pile under the furnace until partly cooled; then it is spread out on a brick floor in front of the furnace and when quite cool is sprinkled with water and thoroughly intermixed. Just enough water is used to prevent any dust from rising when the ore is shoveled over; its consistency is such that it barely adheres when squeezed in the hand. The finer the ore the less water is required.

The ore is next passed through a six mesh sieve; all lumps hereby separated from the mass are ground in a small V mill and re-roasted.

Chlorinating.—The sieved ore is shoveled into boxes holding about 50 pounds each, and these are emptied into chlorination tubs. If shoveled directly into the tubs the ore would pack and subsequently prevent chlorine gas from permeating it freely. The tubs are filled to within two inches of the cover, and the latter is then put on; a groove left around its edge is calked with rags, and the joints are wetted and luted with plenty of tough dough which is kept moist by a covering of wet cloths. Chlorine gas is then passed for 12 hours into the tubs, being admitted into each through a false bottom. Every tub holds 2½ tons of ore, and as much chlorine is used for it as can be produced from 8 pounds of black oxide of manganese, 22 pounds of common salt, and 16 quarts of commercial sulphuric acid of 66° Bé. density. The ore is left in the tubs to digest and chlorinate for two, or preferably, for three days. Chlorination should then be complete, which is tested by withdrawing a cork from the cover of the tub and holding an open bottle of ammonium hydrate over the hole; white fumes of ammonium chloride are seen if the chlorine has permeated the ore to the surface and accomplished its work.

Leaching and Precipitating the Gold.—The gold having been converted into the terchloride by the action of the chlorine gas, is soluble in water and can be leached out of the mass. For this purpose a rubber hose is attached to a discharge faucet, the cover is raised, the ore flooded with water, and the solution

[1] For a more detailed account of the reactions taking place in roasting, the reader is referred to *The Leaching of Ores of Gold and Silver*, Aaron, 1884.

of chloride of gold drawn into precipitating tanks. The ore is kept well covered with the leaching water, which continues to be supplied until the solution running into the precipitating tanks shows no trace of gold when tested with sulphate of iron.

The gold is precipitated in a fine metallic state by a dilute solution of sulphate of iron. An excess of the precipitant is added and the solution well stirred and allowed to stand 24 hours for the gold to settle. The clear fluid is then drawn off, and is either run to waste or collected in a tank where, if worth the operation, the copper it contains is precipitated on scrap iron. When sufficient gold has collected in the precipitating tanks to warrant a clean-up, it is dipped out into a cloth strainer; the water is drained off and the metal dried in a pan over a low fire; then it is melted in a graphite crucible in a small furnace, and run into bars.

Extraction of the Silver.—The silver, mainly converted into a chloride in the roasting furnace, and for the greater part preserved intact during the process of chlorinating and leaching the gold, now remains to be extracted from the ore pulp. The extraction is based on the reaction of calcium hyposulphite and silver chloride, which results in the formation of a soluble double hyposulphite of calcium and silver; the precious metal can be precipitated from this solution as a sulphide by soluble polysulphide of iron, and the simple calcium hypo-sulphite left in solution is used over and over again for leaching.[1]

The ore, deprived of its gold, is left to drain for 24 hours in the chlorination tubs; then it is shoveled into another set of similar tubs, and pure water is run through the mass until the soluble salts of the base metals are well washed out, which is the case when the water coming from the ore gives but a slight precipitate on being tested with a solution of the polysulphide of lime. The ore is then allowed further time to drain thoroughly, and thereupon is leached with the solution of hyposulphite of calcium (or calcic thiosulphate CaS_2O_3).

For this operation the leaching tubs should be kept full of the solution, and the outflow regulated to suit the capacity of the precipitating tanks, the solution pump, etc. The leaching is continued till the solution from the tubs gives but a trace of

[1] The reader is again referred to *Aaron's* work on Leaching for a more detailed account of the reactions in lixiviation, but it must be admitted that many important questions as to solubilities and other points connected with leaching are not as yet answered in technical literature, and that much analytical investigation remains to be made.

precipitated sulphide of silver when a little calcium polysulphide is added to it in a test-glass. This condition is reached in a few hours in treating this particular ore, but two or three days are required to leach some silver ores.

The silver solution having been run into tanks, is precipitated with a solution of calcium polysulphide. Great care is exercised in avoiding the use of an excess of the precipitant, for this would subsequently be carried back into the silver leaching tubs together with the solution of calcium hyposulphite, and would there precipitate silver as a sulphide, which would inevitably be lost. It is always safer to leave a little silver in the hyposulphite solution, for there it is not lost, while furnishing sure evidence that no excess of the precipitant has been used. To detect such excess, take in a test-glass some of the clear solution, from which the sulphide of silver has settled, and add to it a little dilute acetate of lead. This reagent will produce a precipitate of sulphide of lead if a trace of calcium polysulphide is present. If an excess is found, more of the silver solution must be run into the precipitating tank.

The heavy sulphide of silver settles in an hour or two, leaving a clear solution of calcium hyposulphite, which is drawn off into a well, and pumped from there up into a distributing tank for subsequent leaching. The sulphide of silver is cleaned out of the precipitating tanks as often as necessary, and is put into a cloth strainer from which the solution drains off. The sulphide, after drying, is burned in a small reverberatory furnace; the silver is then melted in graphite crucibles, with scrap iron for a flux, and is finally run into bars.

The residue or tailings in the silver leaching tubs, after having been deprived of all mineral of economic value, are discarded. It is claimed that by this process 94 per cent. of the gold, and 60 per cent. of the silver are saved.

Preparation of Reagents.

Chlorine Gas.—This gas is generated in lead vats, 22 inches in diameter and 8 inches deep, set in brick-work over a flue which is warmed to about 90° F. The vats are provided with lead covers having two openings, each 1 inch in diameter, into which lead pipes are luted with flour dough. One of these pipes serves for conducting off the gas; the other for intro-

ducing sulphuric acid. The second pipe is so bent as to form a trap just above the cover to prevent the escape of gas.

Into each generator are charged 9 pounds of black oxide of manganese and 11 pounds of common salt; then the cover is luted on with flour dough, and the sulphuric acid is run in. Commercial sulphuric acid of 66° Bé. density is diluted with water in the proportion of 16 measures of acid to three of water, and 9½ quarts of this solution are used for each generator. The acid is placed in a convenient lead vessel above the generator, and by means of a faucet is allowed to pass drop by drop through the trapped lead pipe into the same. In this way the gas is slowly evolved, at about the rate that it can be absorbed by the ore in the tubs. From the generator the gas passes by one of the lead pipes through a pan of water into a glass bell-jar inverted in the water bath, and thence by a rubber hose, attached to a nipple on top of the bell-jar, to the chlorinating tubs. Two of these generators furnish in 12 hours enough gas for one tub, or for 2½ tons of ore.

Sulphate of Iron.—This precipitant is made by dissolving iron scrap in very dilute sulphuric acid—30 gallons of water to 1 of sulphuric acid. An excess of iron is used.

Calcium Hyposulphite.—This solvent is not prepared directly; the solution for leaching chloride of silver is first made of sodium hyposulphite by dissolving the crystallized salt in water, making a solution of 3° Bé. density. By the leaching operation a soluble hyposulphite of silver and sodium is formed. When calcium polysulphide is added to this to precipitate the silver, calcium replaces silver in the solution. The double salt of calcium and sodium so formed is used as a solvent in the next leaching operation, and in the subsequent precipitation more calcium enters the solution. Thus the proportion of calcium to sodium increases until the solvent becomes practically the hyposulphite of calcium, which is equally effective in forming a soluble double salt with silver chloride.

The use of iron pipes or of an iron pump for this solution should be avoided, as iron is readily attacked by it. Brass should be used instead.

Calcium Polysulphide.—This is made by boiling powdered sulphur and quicklime in water. Into a 100-gallon tub are run 56 gallons of water; when boiling, 35 pounds of lime are

added, and then 15 pounds of sulphur; the boiling is maintained for 5 hours with live steam, and the bath is kept well stirred.

THE MILL.

General Design.—The stamp mill is shown in sectional elevation on Plate I. Special attention is called to the framework of the building, and to the uses which it serves in supporting machinery and shafting. The ore bin, C, furnishes a foundation for the rock breakers B, and grizzlies, A, as well as for the entire upper part of the building. The counter-shaft, T, and the concentrator shafts, L, L, are supported on the roof trusses, while the main line-shaft, K, rests on the battery frames.

Sizing Grates.—The mill is furnished with two sizing grates, or grizzlies, corresponding to two rock breakers. Each grizzly is 4 feet wide and 12 feet long, made of iron bars 4 inches deep and 1 inch wide, set 2½ inches apart and held in place by five 1-inch rods passing through them horizontally, with ferrules on the rods between the bars. The rise of the grizzly is 6 feet 3 inches, which is not very great. The upper end is covered for a length of 4 feet with an iron plate upon which the ore is dumped.

Rock Breakers.—The two rock breakers are of the latest Blake patent, with 10-inch jaws. Each breaker can crush 50 tons of ore in 12 hours.

Ore Bin.—The ore bin is a plain rectangular chamber extending the whole length of the mill behind the batteries. It is 13 feet wide and 11 feet high, and is enclosed by a heavy frame lined with 2-inch planks. The typical inclined back is left out, and the ore is allowed to form its own slope on which it will run; thus the space which generally contains nothing but expensive framework and lumber in most mills is here occupied by a reserve pile of ore.

Automatic Feeders.—Each stamp battery is served by a Hendy automatic feeder, indicated at D. This apparatus is made by Joshua Hendy of San Francisco, and costs $250.

Stamp Batteries.—The batteries have heavy square frames, which are the best form for this kind of mill. Being very rigid, they serve excellently for supporting the line-shaft; they also form a most convenient platform upon which to roll the cam-shafts when it becomes necessary to remove them; and, more important still, they leave the space about the mortars

unobstructed. Complete working drawings of the battery frames are given on Plates II. and III.

The battery screens are No. 5, of the heaviest Russia iron that can be punched. They last about four weeks by reversing.

The mortars weigh 6,000 pounds each.

The weight of a stamp complete is	750 pounds.
The weight of a shoe is	125 "
The weight of a die is	95 "
Shoes of chilled cast-iron last	30 to 35 days.
Dies of chilled cast-iron last	45 to 65 "
Steel shoes last	90 "

As the steel shoes cost 11 cents per pound, and shoes of cast iron 4½ cents, there is not much choice between the two kinds.

The battery blocks shown in the drawings are 10 feet long and set upon rock bottom. Dry blankets are spread on top of these blocks to form a cushion for the mortar.

Amalgamators.—The aprons in front of the batteries are the full width of the mortars, and 4 feet long. They are covered with silvered copper plates, and incline 1¾ inches in 1 foot. Beyond each apron there are two sluices, shown at F; each is 16 inches wide and 14 feet long, covered in the same way as the aprons and having the same inclination. From these sluices the ore slime, or pulp, is carried through launders to the concentrators, G, G.

At the lower ends, or tails, both of the aprons and sluices, there are cross troughs, fitted, as shown, with longitudinal dividing boards, which extend to within 2 inches of the bottom. As the pulp runs into these troughs it has to pass under the dividing board, and in so doing drops the particles of mercury and amalgam which it carries in suspension.

Concentrators.—There are two concentrators for each battery of five stamps, or 16 in all for the 40-stamp mill. These machines are the latest form of Frue vanner, and cost $750 each in San Francisco.

Motive Power and Water.—The whole mill is run by a 6-foot hurdy-gurdy wheel, the invention of Pelton, of Nevada City. The wheel is driven with 104 inches of water[1] under a pressure due to a 390-foot head. The water costs 16 cents per inch, so that the motive power to run the mill for 24 hours costs $16.64. It would require 12 cords of wood to furnish the same amount

[1] An inch of water flowing 24 hours amounts to 17,000 gallons.

of power. In the batteries, on the concentrators, and in the chlorination works 5 inches of water are used and 1 inch is wasted, making altogether 110 inches which the company buys.

Shafting.—The main line-shaft is driven by belting, with two pulleys interposed, from the water-wheel. This shaft is supported on the square battery frames, as represented on "Plan of Top Frame," Plate III, and drives the whole mill, including 2 rock breakers, 40 stamps, and 16 concentrators. It is composed of five sections, as shown in Plate IV in detail. Attention is directed to the form of coupling used, with a projecting collar on the one half fitting into a recess in the other. This device serves to keep the shaft in line if the bolts should not fit the holes in the coupling perfectly; but the same result can be secured by allowing one section of shaft to protrude half an inch, while the other is half an inch short in its part of the coupling, and this form is preferred by some.

Each coupling must be keyed solidly to its shaft, which is then put into a lathe and the coupling faced off perfectly true.

Each section of ten stamps is driven from a friction pulley on the line-shaft. These are iron pulleys with a friction clutch which serves to throw off any section of stamps at pleasure without stopping the balance of the mill.

The main driving pulley and the cam-shaft pulleys are of wood. For pulleys of such large size they are cheaper than if made of iron, and they serve as well. The wooden pulleys are all turned up on the shaft in position.

There are four cam-shafts, each driving ten stamps. They are 5 inches in diameter, and each is driven by a 14-inch rubber belt.

The rock-breaker shaft, T, is $2\frac{7}{8}$ inches in diameter, and is driven from the main line-shaft by a 12-inch rubber belt. Each rock breaker is driven from this counter-shaft by a 6-inch rubber belt.

There are two concentrator shafts running the whole length of the mill, each $1\frac{7}{8}$ inches in diameter. The one nearest the main line shaft is driven from that shaft by a 6-inch rubber belt, and the two concentrator shafts are connected by a 6-inch rubber belt, as shown on Plate I. Each concentrator is driven from its corresponding shaft by a 3-inch rubber belt.

The size of every pulley and its speed are indicated on the general drawing, Plate I.

Cost of Milling.—The mill is so arranged that hand labor is

reduced to a minimum. Eight men suffice to run the mill day and night and keep it in repair. They are distributed as follows: two men by day, and one at night, spall the rock and feed the crushers; three men by day, and two at night, take are of the batteries, tend the concentrators, and deliver the concentrates into the drying room. The immediate daily running expense then would approximate the following:

3 Men at rock breakers	@	$2 25	$6 75
3 " " batteries	@	2 25	6 75
1 Man " concentrators	@	2 50	2 50
1 Foreman	@	3 50	3 50
110 Inches water	@	16	17 60
Wear on shoes			6 11
" " dies			3 42
" " screens			3 87
" " rock breakers, " " concentrators, " " copper plates			5 00
Illuminating			1 00
Lubricating			1 00
Total			$57 50

The average quantity of ore milled per month is 1,850 tons, or 62 tons per day, which brings the cost for milling and concentrating to about 93 cents per ton.

THE CHLORINATION WORKS.

General Design.—The general plan and side elevation, Plate V, show the arrangement of the chlorination works, as well as the frame of the building itself. The floor upon which the sulphurets are dumped when first brought from the drying room of the stamp mill is not shown, but it is level with the top of the roasting furnaces.

Furnaces.—There are two roasting furnaces, placed as shown on the general plan, and provided with a double flue chimney. The details of their construction are shown in working drawings on Plate VI.[1]

These furnaces are built entirely of common red brick, and after two years' constant use they are in good condition. The "Plan of Top" shows the surface on which the ore is first spread to dry and heat. The walls of the furnace extend 10 inches above this level, forming a shallow basin. The ore is

[1] For these excellent drawings I am indebted to Mr. W. H. Englebright, Surveyor in Nevada City.

passed from one hearth to the next one below through ports four inches square, of which there are two in the upper floor, one in the second floor, and four for discharging the ore from the furnace. Each of these ports has a countersunk top, into which is set an iron plug, fitted with a handle for its ready removal. The lower hearth is supported on arches, as shown in "Section through A B." Under these arches the hot ore, as discharged from the furnace, is left to cool. The second hearth is provided with three working doors, and the lower one with four; all of these are arranged with a view to convenience in stirring the ore, and to reaching without difficulty every part of the hearths.

The flame spreads well over the lower hearth; the hot gases passing thence to the second hearth, by two flues shown on "Plan of Second Hearth," are turned in direction and escape through the chimney.

The walls of the furnace are 13 inches thick, and are held securely in place by iron bands and staves. The brick wall is first encircled by three bands of 4 x ½-inch flat-iron, each band consisting of four sections which are drawn together by ¾-inch bolts; then 32 vertical staves of 1 x 3-inch bar-iron are set around the wall, as shown, and these are held in place by three outer bands of 4 x ⅝-inch iron. Each of these bands likewise consists of four sections, drawn together by 1½-inch bolts which have a right-handed thread cut on one end and a left-handed one on the other, with a square section in the middle. The ends of the outer bands are bent to form rectangular loops which are closed completely by welding, as seen in the drawings. The bolts are screwed into nuts placed in these loops.

The working doors are 17 inches wide and 8 inches high at the outside of the wall, but enlarge inward to allow a greater range for the hoe in stirring. In the door-way is set a cast-iron frame ½ inch thick to which the door is hung.

Chlorination Tubs.—These are of peculiar construction. Their capacity is 2½ tons each, and they have the following dimensions:

Diameter at top	5 feet 9 inches.
" " bottom	6 " 3 "
Depth to false bottom	3 " 6 "

The bottoms are made of 3-inch planks tongued together. The staves are of 2-inch stuff with plain joints, but there is a batten ¾ by 2½ inches over each joint, and there are four iron

hoops around all, driven hard. This construction gives a tight tub, and saves the iron hoops from being corroded by the chlorine, as would be the case if they fitted closely to the staves. The cover is made of 1½-inch stuff tongued together, and stiffened by four cleats screwed on top. A jog is cut all around the top of the tub 1½ inches deep and 1 inch from the inside of the staves; the cover fits into this jog, leaving a clearance of 1 inch for calking and luting. An iron bail is bolted to two cleats of the cover to serve for raising it with the aid of a tackle, indicated on Plate V. The latter hangs from a small truck which travels on a suspended track extending over the whole row of tubs. The tubs are provided with false bottoms made of 1-inch boards perforated with inch holes, and covered with a double thickness of gunny sacks. They are supported two or three inches above the bottom by cross pieces.

Leaching and Precipitating Tubs.—The silver leaching tubs are of substantially the same construction as the tubs for chlorination, and the precipitating tanks differ only in being a little shallower, but there is no reason for having them so. All the tubs are painted inside and out with three coats of liquid asphaltum varnish, which should be renewed every year.

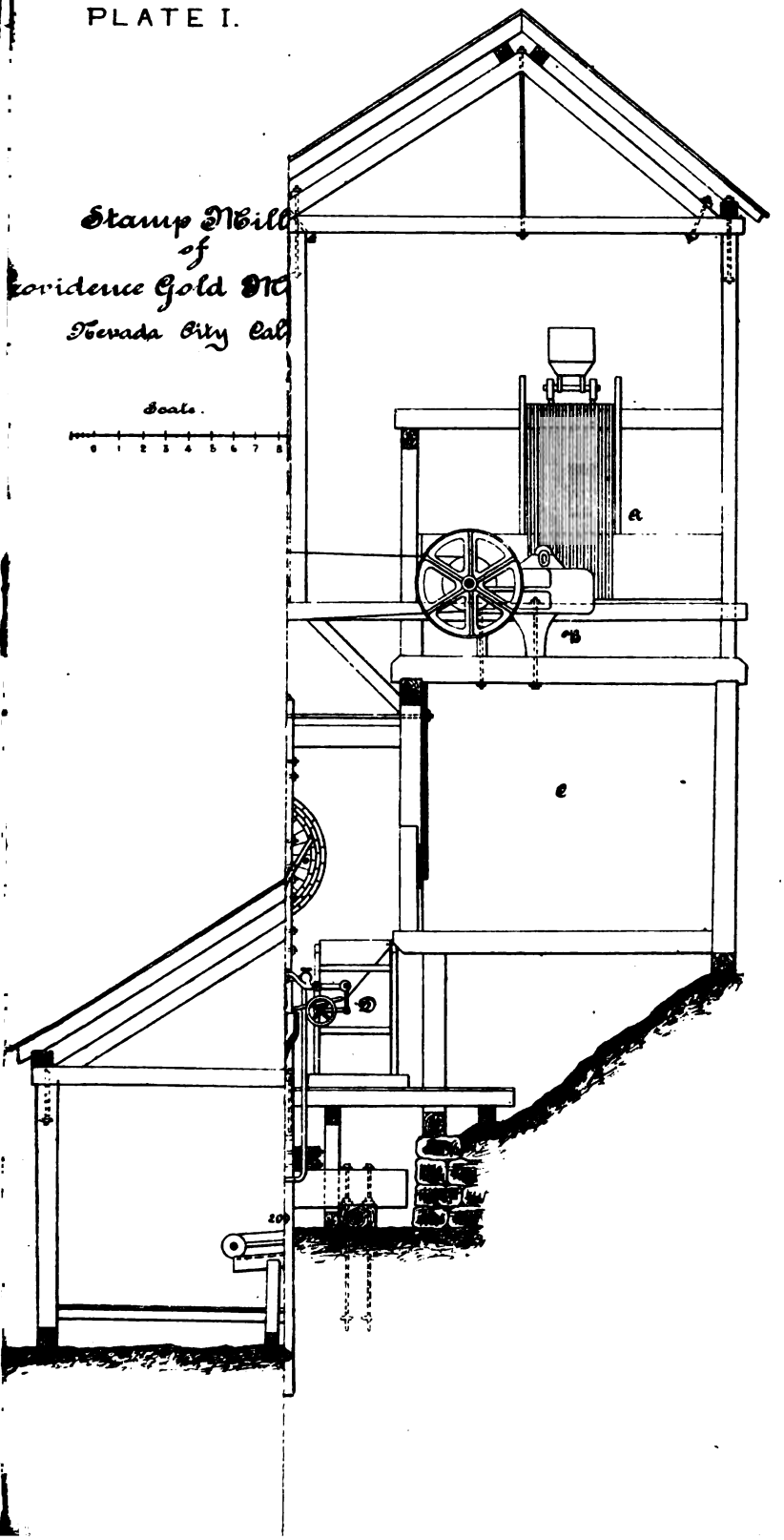
Output, Labor, Fuel, and Cost.—The maximum capacity of the two furnaces is 9 tons of sulphurets in 24 hours. Each furnace burns 1 cord of wood in 24 hours, and requires two Chinamen to work it during that time—the same man tending the whole furnace. Another Chinaman, one white man, and the foreman complete the force for the chlorination works.

The immediate daily expense then would be about as follows:

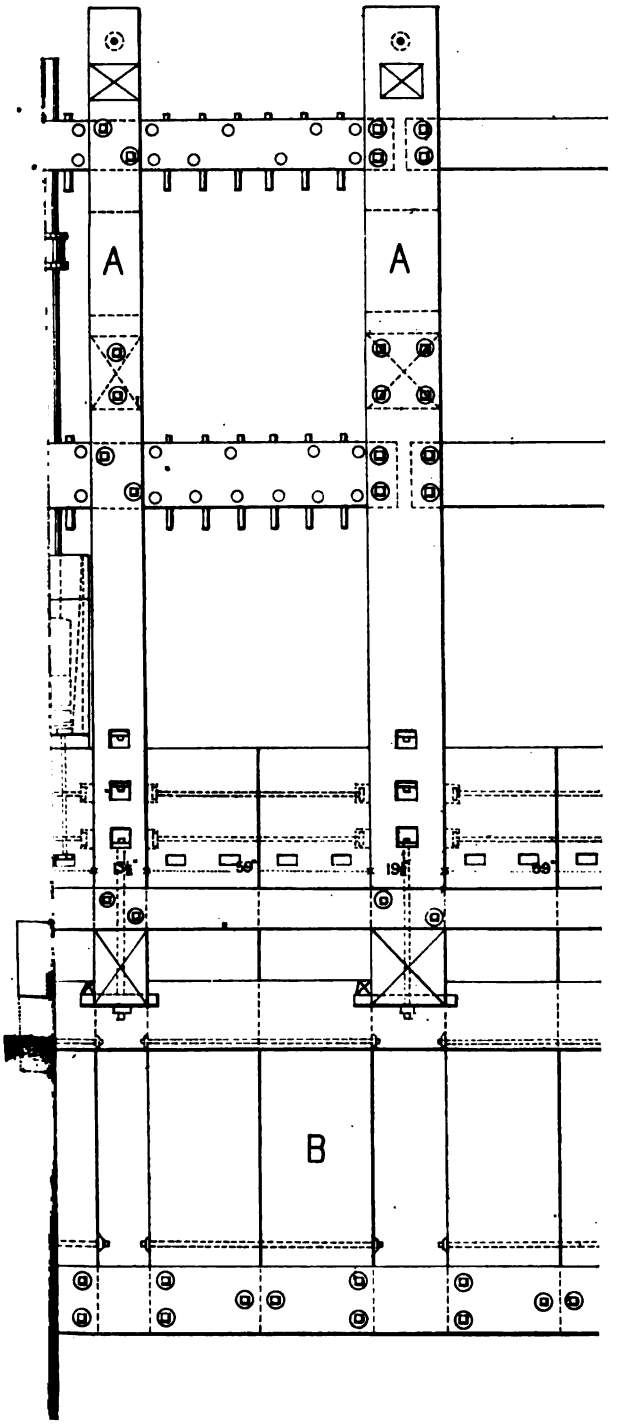
1 Foreman	$3 00
1 White Laborer	2 25
5 Chinamen, at $1 50	7 50
2 Cords Wood, at $5 00	10 00
29 lbs. Binoxide Manganese, at 2¾ cts.	80
260 lbs. Salt, " 1 "	2 60
216 lbs. Sulphuric Acid, " 2 "	4 32
Lime, Sulphur, and Calcium Hyposulphite	30
Illuminating	20
Extras	1 00
Total	$31 97

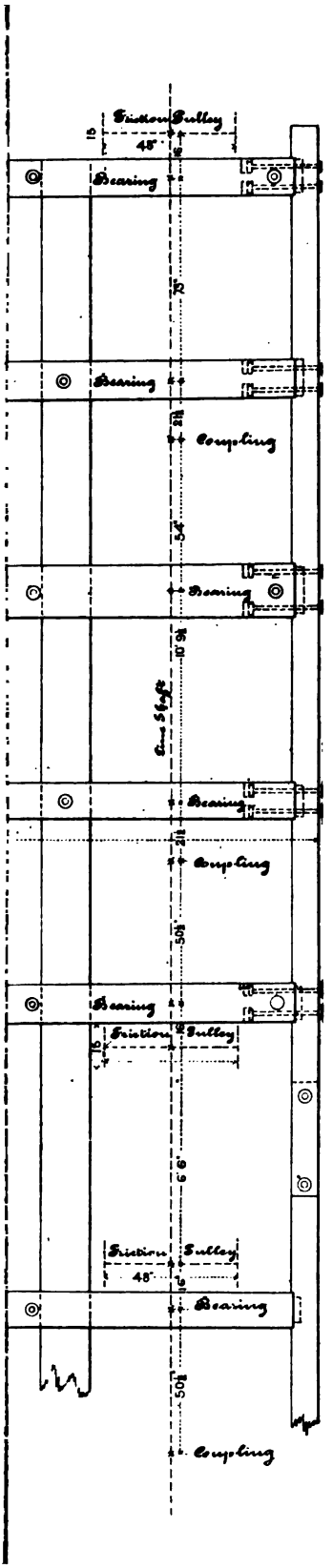
This outlay makes the cost of treatment per ton of sulphurets amount to $3.55, when the works are run at full capacity.

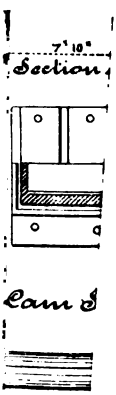
PLATE I.


Stamp Mill
of
Providence Gold Mg
Nevada City Cal
Scale.
0 1 2 3 4 5 6 7 8
A
B
C
D
20

Front Elevation of Twenty Stamp Battery




Friction Pulley
15
45"
16
Bearing
20"
Bearing
2½
Coupling
5'4"
Bearing
10'9½
Line Shaft
Bearing
2½
Coupling
5'9½
Bearing
Friction Pulley
15
6'6"
Friction Pulley
48"
Bearing
5'9½
Coupling


7' 10"
Section
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it 7 per cent
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furnaces run-
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.....$12	75
..... 10	00
.....	38
..... 1	26
..... 2	08
.....	15
.....	20
.....	50
.....$27	32
..... 57	50
.....$84	82

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bove the sea-
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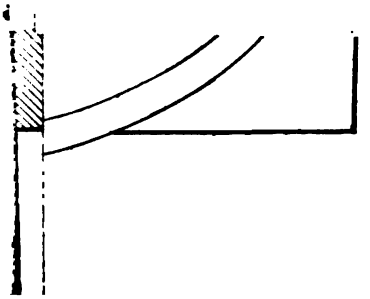
and down-



But the ore contains, as has been stated, about 7 per cent of sulphurets, or $4\frac{1}{3}$ tons in the 62 tons milled daily. Though this quantity of sulphurets does not keep the two furnaces running at full capacity, yet both of them are maintained in continual operation. Most of the expenses remain the same, whether treating this smaller amount or running at a full 9 ton capacity; the actual cost, therefore, figured on a working basis of $4\frac{1}{3}$ tons daily capacity, approximates as follows:

Labor		$12 75
2 Cords Wood	at $5 00	10 00
14 lbs. Binoxide Manganese	" 2¾ cts	38
126 lbs. Salt	" 1 ct	1 26
104 lbs. Sulphuric Acid	" 2 cts	2 08
Lime, Sulphur, and Calcium Hyposulphite		15
Illuminating		20
Extras		50
Total per day		$27 32
Adding to this the cost for milling per day		57 50
The total outlay per day equals		$84 82

or $1.37 per ton for extracting the gold and silver from the ore. This estimate makes no allowance for the expenses of general supervision, interest on first cost, and gradual deterioration.

A GENERAL CLEAN-UP AT THE NORTH BLOOMFIELD GRAVEL MINE.

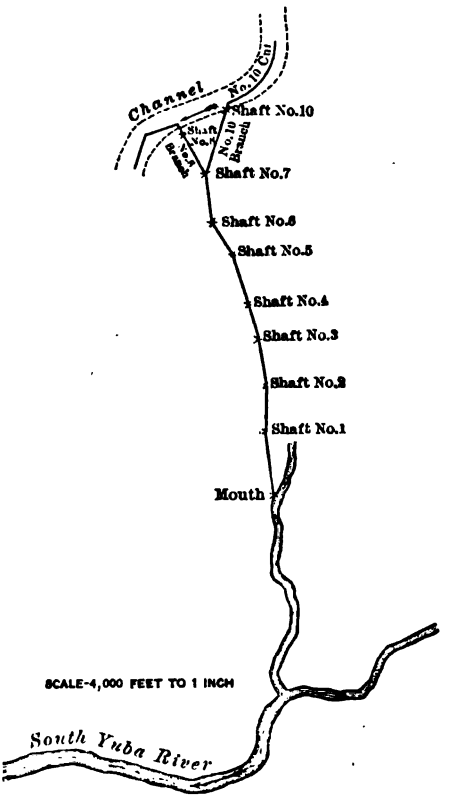
By WILLIAM H. RADFORD, E.M.

As some of your readers may never have witnessed a general clean-up at a hydraulic mine, the following description of the operation may prove of interest to them. To make the subject more clear to those to whom the process of hydraulic mining is unfamiliar, I purpose in the first place giving a short description of the mine. The Bloomfield Mine is situated in Nevada County, California, in what is known as the San Juan Ridge, and runs its tailings into the south fork of the Yuba river. It is at an elevation of 3,200 feet above the sea-level. The mine is being worked at both ends—that is, it is following the old river channel both up-stream and down-

stream, delivering its tailings into the bed-rock tunnel through two branch tunnels, one at the lower end of the mine, 871 feet in length, and the other at the upper end, 1,400 feet long (see accompanying sketch), known respectively as No. 8 and No. 10, so named from the numbers of the shafts at the ends of the branches. Leading to these branches from the headings of the mine are, at the down-stream end, a sluice 550 feet long, paved with block riffles, and an open rock-cut 700 feet long; and at the up-stream end an open rock-cut of 2,000 feet, which is run in the same grade as the sluice in the tunnel, viz., 4′ 6″ to the hundred feet. The sluices in the branch tunnels are 5′ 9″ in the clear and 30″ deep, the bottoms being paved with block riffles 15⅓″ x 15⅓″ x 13″ deep, and the sides protected with side lining blocks 18″ x 18″ x 3″ thick, which reach from the top to within 3″ of the bottom. Below the branch tunnels which come together at shaft No. 7 comes the rock tunnel, 7,000 feet long, at the mouth of which there is a system of tail-cuts, sluices, and under-currents, which all serve to catch the amalgam and free gold that have passed the other parts of the mine. The banks of gravel through which the gold is distributed are washed down and the material runs through the cuts, etc., into the sluices in the branch tunnels, where the larger part of the gold is caught by the quicksilver in the spaces between the riffle blocks. After passing through the sluice, the material, with what gold is not caught, runs through the rock tunnel, tail-cuts, tail-sluice, and finally through the under-currents, after which it finds its way into the Yuba. Taking the upper end of the mine—for, the lower end being out of grade at present, no work is done there unless there is an excess of water or that the upper end is not in condition for use—the regular method during the year is to clean up the sluice in the branch tunnel once in about two weeks, the length of the run depending upon the condition of the riffle blocks, and at the end of the season's run, usually just before the fall rains set in, to clean up all the places through which any gravel has been washed and where any gold is likely to have lodged; this latter constitutes the general clean-up of the mine. For a day or so before commencing the general clean-up, a head of clear water is run through the mine to take out as much of the loose light sand and boulders as possible; then a gang of men goes through and blasts up all the large rocks, chunks of pipe clay, etc., and a second head of water is run through, which puts the

mine in shape for cleaning up with the least work. Starting at the lower end of the rock tunnel and at the same time at the lower end of the rock-cut, lines of small sluice boxes, 12″ wide and 11″ deep, tapered at the ends to fit into each other, are set, and everything in the bottom of the tunnel is shovelled into these sluices and washed with a small head of water over the cross riffles with which they are provided. After the loose stuff is all shovelled in, the men go to work with iron scrapers, hooks, etc., and clean out every little crevice and hole in the rock; where the rock is soft and seamy they pick it up and throw it into the sluices, as the gold will work down to the bottom of the smallest hole. Whisk-brooms are used for sweeping out the cracks, and silver spoons for picking amalgam and quicksilver out of the holes. This method is carried out for the whole length of the tunnel, and the same operation is conducted in the rock-cut leading to the sluice, the gold in the cut being of course bright gold, while nearly all found below the sluice will be amalgamated. The cleaning-up in the cuts and sluices at the lower end of the mine is usually done a month or so before the work at the upper end is commenced, so as to have plenty of men; but the principle is precisely the same. After the tunnel and rock-cut are thoroughly cleaned up, a head of water is turned on and run through the mine, which works down any gold in the cut that may have remained into the sluice. This is next cleaned up by taking out all the riffle blocks and allowing the amalgam and heavy material to fall on to the bottom. The head of water used during the operation carries off the lighter portion and leaves the amalgam dragging behind, which is scooped up and put into buckets; when the end of the sluice is reached and all the amalgam taken up, men go over the whole bottom with silver spoons and pick the amalgam and quicksilver out of every crack and nail-hole. When this is finished, another head of water is run through which carries anything that may be left, down again through the tunnel to the under-currents, tail-cuts, etc. Of course, a little from the sluice is caught in the tunnel, but the amount is small, as the work in the sluice can be pretty thoroughly done. The tail-cuts are cleaned up in the same way with the use of little sluice-boxes; the tail-sluice, which is usually paved with rocks, so as to run a longer time, is cleaned up in the same manner as the main sluice, and the under-currents, which are only broad sluices paved with either longitu-

dinal riffles, rocks or blocks, as the case may be, are treated in the same way as the sluices. Opportunity is taken while the water is out of the mine and ditches, to put everything into thorough repair for the coming season. The quicksilver on hand which has been in use during the year is retorted, as it is found that some gold remains in it, after straining through drilling, the result being enough to pay well for the cost of retorting. By this time pretty much all the gold is collected and the mine put into shape for the next season's run.



The little sluice boxes, unless in very good condition, are taken apart and burned and the ashes gathered up and panned out, yielding usually enough to pay for the price of the boxes. The tunnel is cleaned up in sections, a gang consisting of six or seven men starting with its line of boxes say one hundred and twenty feet long, at the sump of one of the shafts and walking up to the next sump above, where gang No. 2 has already started. In this way the tunnel is cleaned up in about three or four days, the old and trusted hands taking the head section, which is of course the richest. The accompanying table will show the length of each section and how many ounces of amalgam it produced. The gold obtained at the general clean-up just past, amounting to $106,553.74, is the result of a season's run of twelve months and twenty-four days, during which time 79,437 miner's inches (one miner's inch = 2230 cu. feet) of water were run at No. 8 and 865,296 inches were run at No. 10, with a total yield, including the general clean-up, of $525,797.30, giving the

percentage of gold for the general clean-up this year as $20\frac{2}{10}$ per cent. of the whole amount.

Amalgam Obtained from Sections of Rock Tunnel.				Sources whence Gold was Obtained at General Clean-up of 1883.			
Section.	Length in feet.	No. of Ounces.	Value.	Source.	Oz. of Amalgam.	Value per oz.	Value.
Mouth up to No. 1 shaft	1509	147	$872.60	No. 10 Cut	5,091.5	$13.01	$66,293.29
No. 1 shaft up to No. 2.	929.2	148.5	881.49	No. 10 Flume	713.	7.55	5.383.15
No. 2 " " " No. 3.	906.5	222	1,317.87	Tunnel	4,466.	5.94	26,512.14
No. 3 " " " No. 4.	907	228	1,353.55	Tail Cuts	356.	6.01	2,142.25
No. 4 " " " No. 5.	883	410.5	2,436.97	* Tail Sluice	131.75	5.50	724.62
No. 5 " " " No. 6.	904.4	700.5	4,158.66	* Undercurrents.	285.	5.50	1,017.50
No. 6 " " " No. 7.	962	2609.5	15,491.00	No. 8 Cut	591.	7.58	4,480.79
Total	7007.1	4466	$26,512.14	Total	11,534.25	Av. 9.23	$106,553.74

* Were cleaned up during the year. The amount from the tail sluice is the result of about one and a half months' run, and from the undercurrents is the result of a two months and a half run.

ERRATA IN VOL. V. NO. 3.

Page 241, line 21.—For (5) $b + c = x + y + z$ read (5) $b + c = x + y + 3z$.
Page 273, line 19—For *casting* read *soaking*.

PROFESSIONAL NOTES.

METALLURGY.

The Siemens Furnace.—Generally the Siemens furnace is used for making Martin steel. Only occasionally, as at St. Chamond, in France, and at the Cambria in this country, the Pernot furnace is used. This rotating hearth works quicker, but is more expensive and gives a less uniform product.

Charges of from two to twenty-five tons are made in the Siemens furnaces. The average is about eight tons, as they are less difficult to work than the larger furnaces, which, however, can be kept longer in work, and use less fuel. Very often large furnaces have too small regenerators, in which case the quantity of fuel used is much greater per ton than in the small ones.

The volume of the laboratory occupies a space according as the work is done with or without the addition of ore, from 12 to 30 per cent. greater than the space taken by melted material, and the three dimensions are determined according to the quantity of gas and the greater or less oxidation which it is desired to give. The length must be determined so that the gas will be entirely burned in the laboratory, and not pass over the bridge into the regenerator flue. The length of the hearth is determined by the fact that the burning velocity of the usual producer gases is about two meters per second. This, however, will be determined by whatever coal is used. The length of the laboratory is generally too small, which makes great difficulty with the regenerators themselves and the flues which lead to them; as, for instance, at Firimini works it is $3\frac{1}{2}$ meters per ton an hour, while at Borsig's works it is 6 meters for the same width of furnace.

The depth of the bath is dependent upon the relative quantity of cast-iron, crop-ends, and ore. When there is but little cast-iron and a great many crop-ends the depth is greater. When there are less crop-ends and more ore, less deep, because oxidizing action increases with the size of the surface. When much ore is used the largest possible surface is given, that quantity being determined by the quickness of the oxidation. When there is a very large surface the oxidation goes on without any unnecessary addition of ore very quickly, as the ore, when the process is rightly managed, is reduced in the mass, so that the slag contains almost as little iron as light green Bessemer slags. When there is not a sufficient surface when the oxidation is rapid, large pieces of ore must be put in, as they sink better into the bath and increase the movement between the melted material and the ore; but on account of the rapid melting of the ore the action soon stops, so that the reaction between the melted slag and the upper surface is not rapid. When the bath is shallow the heat goes easily through it, which is necessary when the fuel is not a good one, and when the gases are not very highly carburetted. The width of the laboratory is determined by the two other dimensions already given. The side walls on the line of the slag must have a covering of some inches, in order to protect the refractory material. The hearth

is made by putting upon the three iron bedplates, whose middle is horizontal and sides are inclined, a layer of dinas bricks, which is covered over with quartz sand about the size of a pea, mixed with two to five per cent. of clay, and stamped ; or, after the completion, drying, and heating of the furnace, sand with a known quantity of silica is placed on the hearth in a layer which is two centimeters in depth, and thus sintered. In this way several layers of sand are sintered together, so that the hearth in its thinnest point—that is, by the tap-hole—will be at least 50 cm. thick. In the Austrian works, Vienna sand is used, which contains 86.3 per cent. of quartz, 7.9 per cent. feldspar, and 5.8 per cent. of basic material.

The fire bridge must be made out of dinas brick, and it is generally best that the bottom should rest on one of the inclined plates of the bottom plate. This is the disposition at Krupp's works. This allows of cooling the bridge, and when the bath eats through near the fire bridge, by spurting water from the under side against the corroded portion, the bath will be rapidly cooled, and it will be possible to cast, so that the repairs may be undertaken at once.

Open fire bridges, in which the gas and air meet directly over the regenerators, are less common than closed ones, forcing the gas and air to mix in the furnace itself. They both enter the furnace at the same height from openings by the side of each other, as at Graz, Bochum and Firimini, or the gas enters from two openings, above which is the air plate, as at Phœnix, Borsig's Works, Witten, Plantey and Blahairine, or there are two openings for gas and three for air which lie in the same plane as those for gas, or are in the middle and upon either side, as Landore, Dowlais, Elba Steel Works ; or there are five to seven openings of the same height, which are used alternately for gas and air as at Krupp's, Terre Noire and Firimini, and this is the best and most complete method of burning the gas. This disposition in the French works leads to a considerable oxidation of the iron, as the iron is more exposed to the gas than in the other method.

The method in which the air openings are higher than the gas openings, makes a better mixture, as the heavier air sinks, which does not take place when, as is generally the case, the air regenerators are made larger than the gas regenerators. It is then generally the habit to make the temperature of the air greater than that of the gases, so that the specific gravity of these latter is somewhat greater than that of the air. Cooling pipes in the fire bridges and in the rows between, sometimes, as at Witten, make the furnace too cool.

Martin furnaces are seldom blown by engines as in Sweden, in which disposition, the sum of the sections of all the fire openings must be at least one-third greater than the open section of the fire surface, and the air openings must be half as large as they are. With open fire bridges, as is general in Sweden, the surface of the opening of the partition wall between the air and the gas generators must have half the area that it has over the fire bridge ; and this opening is somewhat larger than the open surface of the generators.

In order to save room and foundations, the regeneratorsare almost exclusively under the furnaces, and are almost wholly regenerators for air and gas; much more rarely are they used for air only, as at Witkowitz, as it renders a much larger amount of fuel necessary. Instead of making the air regenerator only half that of the gas, it is recommended, with the exception of the use of coke gas, that the air regenerators be

ten per cent. greater, in order to have the temperature of the gas and air alike. If the sum of the volumes of the air and gas regenerators is divided by the number of tons of steel produced per hour, the following results are shown for different furnaces:

	CUBIC METERS.
For Dowlais	14.60
Graz	16.50
Hallside	16.75
Krupp's new Furnace for 8 tons	18.32
Landore	20.10
Panteg	20.60
Large Furnace at Terre Noire	30.
Krupp's original 3-ton Furnace	36.
Borsig's Works	44.

The arch of the furnace in England generally sinks deep into the middle of the hearth and rises very high at both ends of the oven, which causes a very great loss of the heat. At Phœnix and Firimini the arches over the regenerator flues and the fire bridges are too much inclined towards the hearth, but over the hearth they are horizontal. Those which last the longest are those which both over the hearth and fire bridges, and regenerator flues are provided with cupelle arches as at Graz, Autin, Witkowitz and Ibiswild.—*Berg und Hütten. Zeit.* 1883, p. 345. T. E.

METRICAL EQUIVALENTS.

On more Convenient Equivalents for Converting British into Metrical Measures than those hitherto in use.—G. J. Stoney, F.R.S., gives in NATURE the following revised tables, based on Captain Clarke's determination of the length of the British yard in metrical measure, made in 1866.

TABLE I.

MEASURES OF LENGTH.

The yard	= 914.4	millimeters.
The foot	= 304.8	"
The inch	= 25.4	"

TABLE II.

WEIGHTS.

The pound	= 453.6	grammes.
The half-pound	= 226.8	"
The quarter-pound	= 113.4	"
The ounce	= 28.35	"
The grain	= 0.0648	"

The gramme = 15.43210 grains [a number very easily remembered].

TABLE III.

MEASURES OF CAPACITY.

The gallon	= 4544	cubic	centimeters.
The quart	= 1135	"	"
The pint	= 568	"	"
The half-pint	= 284	"	"
The noggin	= 142	"	"
The fluid ounce	= 28.4	"	"

"If any person using these tables wishes to carry refinement further, he may do so by subtracting one in every hundred thousand after using Table I.; by subtracting one in sixty thousand after using Table II.; and by subtracting one in ten thousand after using Table III. These corrections will carry accuracy to the limit of Professor Miller's and Captain Clarke's determinations." J. K. R.

SCHOOL OF MINES NOTES.

ENGINEERING SOCIETY OF THE SCHOOL OF MINES.—The officers for the second term are as follows:

President, W. Newbrough; First Vice-President, J. I. Northrop; Second Vice-President, A S. Dwight; Secretary, H. N. Pierce; Treasurer, A. T. Lamb.

Since the last notice meetings have been held as follows:

February 21st, 1884: "Construction and Management of a Charcoal Blast-furnace in Maryland," A. T. Lamb.

March 7th, 1884: "The Interlocking Switch and Signal System of the United States Railways," J. T. Horn.

March 21st, 1884: DEBATE: "*Resolved*, That Belting is preferable to Wire Rope for transmission of Power for distances of from 50 to 60 feet. Affirmative, Messrs. Moran and Fowler; Negative, Messrs. Gosling and Corcoran.

After the debate the votes taken resulted as follows: On the merits of the question, Ayes, 12; Nays, 2; on the merits of the debate, Ayes, 14; Nays, 0.

Mr. Pearis then read a paper on "Leaching Silver Ores in Nevada."

April 5th, 1884: LECTURE: "Treatment of Gold and Silver Ores" with lantern views, by Dr. P. de P. Ricketts.

At this lecture Dr. Ricketts first spoke of the usual methods employed in the West for treating Gold and Silver Ores, and illustrated his remarks by diagrams arranged as trees. After explaining these methods, he gave lantern views, showing the different furnaces, tubs and other appliances employed in the West, thus affording a clear idea of the various processes. At the conclusion a vote of thanks was tendered to Dr. Ricketts by the Society. W. N

The last public lecture of the season before the Society was given by Dr. R. W. Raymond, Friday evening, April 25th, 1884. Subject: "The United States Mining Law."

In introducing it, the lecturer spoke of the art of mining as a fundamental industry, and then outlined the principles of the laws and their changes from the time of the Phœnicians through the middle ages, to the present day.

Finally, in speaking of the United States, Dr. Raymond showed what great inconvenience and endless litigation the want of a definitively prepared and comprehensive national mining code had occasioned.

S. S. F.

CHEMICAL SOCIETY.—A regular meeting was held May 8th for the election of officers for the coming term.

The balloting resulted as follows:

President, Mr. F. J. H. Merrill; *First Vice-President*, Mr. P. Moore; *Second Vice-President*, Mr. R. Van A. Norris; *Treasurer*, Mr. J. F. Carter; *Secretary*, Mr. H. Hollis; *Editors of Quarterly*, Mr. F. J. H. Merrill, Mr. R. Van A. Norris, Mr. J. Carter.

Mr. Dwight's resignation as a member of the Society was accepted. The Society then adjourned.

LIBRARY NOTES.

SINCE the six libraries of Columbia have now been erected into a distinct department of the university organization, we shall hereafter give notes of interest to our readers, grouped together under the above heading. By vote of the Trustees, students of all the departments have equal privileges in the entire university library, and graduates of all the schools are given, without the formality of asking, the same privileges as active members of the College. This liberal action gives our readers new interest in everything connected with the Library.

Though occupied October 1st and in daily use, gangs of workmen have since been constantly engaged in the interior. This is now rapidly approaching completion. The central curtain between Loan and Reading Room and the shades to the south and east windows are up; the hearth-stones are set in the great east and west fire-places; the three hoists for books and the corner closets are finished; four large additional radiators have been set, as it is guaranteed that the great Reading Room shall be heated to 20° C. (68° F.) even in the coldest weather; the large ventilating registers in each corner of the Reading Room are set, and the powerful draft made by 600 feet of steam pipes in each, with the large registers near the ceiling and the pure air supply from the ten perpendicular registers near the floor, secure perfect ventilation, so that on the closest days, when the room is filled, there is not the slightest ground for criticising the quality of the air. Thermometers, both Centigrade and Fahrenheit, have been hung freely about the building, and these, not the temperature of the janitor, are to control the supply of heat. The steam coils in the air-chambers in the basement are so arranged that they can be used at either whole or half power, and registers in the Library completely control the heat.

At the right of the entrance is the Loan desk, the only place where books can be charged or returned. A double oak settee stands across the broad hall just inside the open doors, leaving only a narrow passage next the desk, through which every person must enter and leave the Library. The upper Reading Rooms and stack rooms are reached only hrough the main hall, as the other entrances are kept locked. A Librarian or assistant is always on duty at this one entrance during all hours of opening, and sees every individual when he comes in and again when he leaves. Thus the danger of improper persons getting access to the Library, or of books being carried away without charging, is reduced to a minimum.

With these precautions, the Library is able safely to grant to those who are admitted very unusual privileges in access to the shelves of the Reading Room, with its 25,000 volumes for reference. Graduates and others entitled to the use of the Library, after being once identified at the gate, have free access.

Others known to the Librarian, or satisfactorily introduced, receive readers' tickets, which are not required to be shown after the attendant recognizes the holder as a reader.

This simple plan protects the Library against the professional book thief, so common in great cities, and so often well-dressed, scholarly in appearance and often in fact, and against whom there seems no protection except exclusion of strangers until vouched for. The cordial reception and extra privileges then granted make double amends for the slight preliminaries.

Running ice-water comes through the wall near the entrance, and at the Loan desk coats, hats, umbrellas and small packages are received and checked without charge. To accommodate readers a district messenger call-box is placed at the Loan desk, and telegrams can be promptly sent without charge to any line, or messengers can be called for local errands. Ten double settees of oak, scattered about the Loan room and the entrance hall, will afford seats to those who wish to converse, thus leaving no excuse for violating the rule of strict silence on the south side of the curtains.

Under each of the windows is fitted a cosy oak seat for two. The fronts of all these seats are hinged to the floor, so that twenty-six locked closets are scattered about the room for the use of the staff or readers needing them. To reach the higher shelves without the annoyance and danger of step-ladders, bronze steps and handles are fitted to each upright wherever in the building any shelf is above the reach of a man of ordinary hight. In the door of the Chief Librarian's room a letter-box has been placed to receive recommendations of books to be added, notes, suggestions or criticisms concerning the Library or its management, either signed or anonymous, such evidences of active interest being not only received cordially, but esteemed a favor by the management.

All the departments are immediately connected by electric bells, annunciators and speaking tubes. The bells are of different tones, to avoid mistakes, and, instead of the common *whirr*, are single stroke, and are largely used, like a telegraph key, to indicate a simple message by the strokes and intervals, without using the speaking-tube. The tubes have all been laid with curves instead of right angles, and instead of requiring the voice to be raised, they transmit the lowest tones audibly. By means of switches, devised for this building, the various tubes can be connected like the wires in a central telephone office. Thus much loss of time and confusion is avoided. Book trucks, balanced on large rubber wheels, enable a page to carry rapidly and noiselessly about the room or balconies 200 volumes at a time, and book trays, with rubber feet and broad carrying-straps, serve a similar purpose for small loads.

The pages wear slippers, and when the workmen, with their unavoidable noise, are out of the building, it is thought that these various precautions will secure unusual quiet for study. To accommodate those wishing to read after dark, before the electric light was ready, a quantity of duplex student lamps were supplied, but in the third week in March were replaced by electric student lamps on each table, thus securing a less injurious light to the eyes than is possible from any system of lighting from above. The electric lights are supplied for all the shelves as well as the tables, so that every book is as available by night as by day. Sixty oak reading tables have been provided, all carefully adjusted to the wants of students. On either side long slides may be drawn out for reference books; the braces at the bottom are arranged in a cross, so that there is free space for the feet on all four sides. Both arm and ordinary chairs are of Austrian bent-wood, mahogany finish, with cane

seats and back, light, strong, and with the back legs shortened, so that they are very comfortable for protracted use.

At the left of the arch the tables are reserved for the Law School, the walls of the east end being entirely covered with law books, and Mr. G. H. Baker, the librarian in charge of Law, Political Science and History, having his desk there. Labels have been hung on the law shelves showing the chronological order of the reports under each State as arranged on the shelves. Shelf-labels with class numbers and subjects are also being placed all through the Library; also iron book-supports to keep the books upright on the shelves.

At the right of the main arch Mr. W. G. Baker, librarian in charge of Science and the Arts, has his desk, and behind and at his right, extending to the door of the office, are the serials and most of the reference books, of which he has special charge. On both desks are kept, for the use of readers, blocks of paper of letter, note and postal sizes.

For convenience of direction and reference, the entire building has been lettered and numbered, but the books themselves are arranged not by these numbers, but by subject or class numbers, by a simple and convenient system which will be explained in a future number. The system of numbering adopted gives first the number of the floor counting the basement 0, the Forty-ninth Street floor 1, and thus the Reading Room is 3, and the balcony on the same level as the small reading room 4, etc. The rooms are lettered A, B, etc., counting from left to right from the main entrance to each floor; then in each room the sides or *faces* of shelving are numbered and each *tier* of shelves lettered and each *shelf* numbered top to bottom. In the old fixed system the books would then be numbered on each shelf left to right, but this is superseded by the better relative location—*e.g.*, 52 E 4 is the 4th SHELF from the top of the E or 5th TIER of shelves in the 2d long FACE running east and west on the 5th FLOOR. As there is only one room on this floor at present, no room letter is used between 5 and 2, and no confusion is possible, as there are not more floors than nine, so only one decimal place can be used for the floor; 52 E 4 *must*, therefore, mean 5th floor, 2d case, 5th or E tier, and 4th shelf. These numbers have been painted on the iron and oak shelving in all the stack rooms. In the main Reading Room large letters on the brick above the balcony cases mark off the main sections of the room, beginning at the entrance with A and giving a letter to each space between the beams of the roof. The same letters are repeated beneath the balcony on the iron brackets.

The present arrangement of books of the floor is: History and Sociology, A—E, *i. e.*, the east side of the Loan Room; Law, F—K, *i. e.*, the east end of the Reading Room to the middle aisle; General Cyclopædias and Periodicals, L—P, *i. e.*, the west half of the south side to the west fire-place.

The accession, catalogue and shelf departments occupy O—T (from west fire-place to the office door).

Books just added are kept on exhibition for one week before going to their regular places or being loaned. These have the tier east of the office door, and are followed by the most used dictionaries, gazetteers, etc. Next come current numbers of periodicals, in special charge of the Science librarian, and, again passing through the arch, Natural Science and Useful Arts occupy V—Z, except the space used by the coat room and Loan desk.

In the balcony, Literature (except Latin and Greek, which is in 4) fills A—D. The Anderson Library of pure mathematics is in G and H. The Phœnix Library fills I—P, *i. e.*, all the south balcony from east to west fire-place.

The reference books on Science and the Useful Arts, including bound periodicals, transactions of societies, etc., occupy from Q—Z, or from the west fire-place clear around to the entrance door.

Philosophy, Philology and Latin and Greek Literature, with Fine Arts, have the private reading room No. 4. Theology, public documents, patents, duplicates, college publications, etc., are in No. 5, and the Botanical Library and Herbarium go in No. 6. The 7th floor is divided into computing rooms for Prof. Rees' department of Geodesy and Astronomy, and the 8th floor is the Observatory. There is also independent access to these rooms without passing through the Library.

The fifth floor has the center filled with iron cases of oak shelving, each shelf 75 cm. long and all interchangeable. The aisles are also 75 cm. wide, being made by omitting a tier of shelves. The shelving is marked like avenues and streets, the east and west being numbered, the north and south lettered. Electric lamps hang on flexible cords, and a touch turns the light on or off, so that there is no difficulty in reading the titles in the midst of the stack on the dark days or at night. At either end is left a private reading room, with tables and chairs, and under all the windows are handsome oak cases, fitted with movable partitions for large folios. Four locked closets accommodate special readers, and tubes, bells, and hoists communicate immediately with the Loan Desk. This floor holds 40,000 volumes, and twenty readers might work in the two private reading rooms.

The fourth floor has only wall shelves, the entire floor-space being filled with readers' tables. Over each is a hanging electric lamp, balanced like a window-shade, so that it will remain at any height the reader chooses to place it. To No. 4 and No. 5 readers are admitted only by shelf-permits, which are given to those making special investigations or needing special accommodations.

The packing and storage rooms are on the first floor, below the main entrance, as is also the toilet room for the use of readers, while on the reading-room floor is a private toilet room for ladies.

Lights have been placed at the entrance to the grounds, and at the stone-terrace steps, and every night except Sundays, throughout the year, including holidays and vacations, the entrance and building are perfectly lighted till ten o'clock. For any who prefer a less powerful light, ten-candle lamps are provided instead of the sixteen-candle preferred by most readers. The student-lamps and shelf lights have been perfected in consultation with Dr. C. R. Agnew, the famous oculist, who as a trustee of the college has taken the warmest interest in securing the most perfect light known for the library. Opaque shades throw all the light on the tables and on the shelves, so that the eye of the reader, raised from his book, meets no annoying glare of direct light. The light is reflected from the backs of the books with a warm, soft effect that is very pleasing. In its practical workings the electric light has met all expectations.

Of the very interesting methods of cataloguing, classification, and arrangement of books, we shall make brief notice in a future number.

BOOK REVIEWS.

Text Book of the Principles of Physics. By Alfred Daniell, M.A., Lecturer on Physics in the School of Medicine, Edinburgh. Macmillan & Co. 1884.

As the title of this work shows, it does not pretend to be a complete treatise on physics, but only on the principles of physics. The book is none the less welcome on that account, however, but indeed more so; for it is somewhat to be feared that the too luminous exposition of the observed phenomena of nature at the expense of the laws which control these phenomena may obscure our mental vision when we seek to peer into the future. As theory without facts is of no value, so facts without an accompanying theory are of but limited value. In accordance with this idea, we find that this work is lacking in the descriptions and figures of apparatus which play such a prominent part in most text books on physics, while on the other hand it goes more deeply than most other text books do into the underlying principles through which these apparatus are rendered effective. Its illustrations are given with this object in view, and are diagrams explanatory of the text.

The first subjects treated are the fundamental ideas of time, space and mass, and those dependent on them of motion, force, work, etc., with the general measurements employed. The principles of kinematics are then taken up, with a very complete discussion of wave motion, in which we find explanations of reflection, refraction, polarization and interference phenomena, which are afterward employed in the chapters on sound, light and heat. The diagrams given in explanation of these phenomena are well drawn and lucidly explained.

Next in order is Kinetics, and following this a general consideration of attraction and potential, without particular reference to any one form. A particular case—that of Gravitation—is now considered, and the principles previously discussed are applied to it. It is shown that the proposition "that equal masses of different substances have equal weights," is one that requires experimental proof, for when we consider another form of attraction—that of magnetism—we see that equal masses of different substances, such as iron and wood, are not attracted equally.

The properties of matter are next considered, with discussions on molecular physics, the kinetic theory and the ether. Separate chapters are devoted to solids, liquids and gases.

After these discussions of the forms of matter we come to the various forms of energy acting on matter without the application of visible impulses. The first of these in order is sensible heat, as distinguished from radiant heat, the former being the final form into which all energy is converted, so far as we yet know. The effects, transformations, measurement and transference of heat are separately considered.

Under Sound we find ourselves referred again to the general phenom-
of wave motion treated of in the earlier part of the book; the
l scale, with the frequency of vibration corresponding to different

notes; the intervals between them, harmony and discord, beats, the analysis of sound into its component tones, the laws of vibration of sounding bodies, the formation of nodes, diffraction, refraction, reflection and interference, are all separately discussed. A few pages are devoted to the mechanism of the ear, by which the sound vibrations are made evident to our sensory apparatus.

The next chapter treats of Ether waves, this term being used with reference to radiant energy. It is shown that there is no difference in kind, but only in degree, between radiant heat, light and actinic rays. Polarization and double refraction are treated of, with mathematical explanations and diagrams.

Electricity and magnetism are defined as being neither forms of energy nor of matter, but probably conditions or properties of matter. The difference of potential produced by the contact of dissimilar substances leads to the consideration of galvanic cells and of thermo-electricity. The various facts of electricity are briefly but clearly discussed.

At the end there is a useful list of works on physics classified according to subjects, and brought up to within a few months of the present time.

The book is well provided with references to the practical application of the principles set forth, and is written in a peculiarly clear and pleasant style. The use of solid-faced type and of spaced words emphasizes the statements of the writer, and makes it easy for the student to apprehend the subject to which his attention is directed. Interspersed in the main body of the text are paragraphs in development and illustration of the subjects treated, together with numerical problems for the student to work out, which are printed in small type, so that the main thread of the argument may be followed without trouble.

To the student wishing to know the "reason why," this book will be of great service; to the mere superficialist it will probably be disappointing. †

Absolute Measurements in Electricity and Magnetism. By Andrew Gray, M.A., F.R.S.E. Macmillan & Co. 1884.

This little book is written in a style which it would be well for many authors to copy. It is clear in its expositions, and without unnecessary detail leaves little to the imagination of the reader, who is often only too apt, when confronted by mathematical formulæ, to take for granted the correctness of the proofs put forward without thoroughly understanding them. Mr. Gray has evidently taken pains to be well understood, and is not alone content to describe methods, but also shows why they are employed, and what precautions are necessary to obtain accurate results.

The subjects treated cover practically the whole ground, including the measurements of the magnetic constants, currents, resistances, energy, efficiency and potential; the construction and gradation of instruments, the definitions and relations of the various c. g. s. units, and of those practically employed, and a chapter on the use of dimensional formulæ, illustrated by examples.

Among these we may instance as of practical value the chapter on the measurement of resistances, including both very small and very great, the reasons for the methods described being clearly set forth, so

that the reader may fully understand them and have confidence in their use.

At the end of the book are appended a few tables of the resistances and conductivities of different sizes of wire, specific resistances of metals and alloys, conductivities of different metals, and the electrochemical and thermal equivalents in absolute measure.

We note some few errata which have escaped notice, but these are of such a nature as to at once be evident on comparing the context. Our estimate of the value of the book as a whole may be best expressed by stating that in our opinion the author has fully succeeded in carrying out the design embodied in the following words of the preface: "It is designed to give as far as possible within moderate limits a clear account of the system of absolute units of measurement now adopted, and of some methods and instruments by which the system can be applied in both theoretical and practical work." †

Heat. By P. G. Tait, M.A., Sec. R. S. E., London, 1884: Macmillan & Co.—The author prefaces his book with an apology for presenting another treatise upon a subject which has been thoroughly and excellently handled by others. But he explains that of the former works, some have treated it theoretically and others experimentally; while his book is especially adapted for those who desire an elementary and a practical knowledge of the subject.

Although not designed for advanced students, it may be read with profit by any one.

The chapters on "Change of Molecular State" and "Thermo-Electricity" are written in a particularly clear and novel manner.

The diagrams and illustrations, which are numerous, are of great assistance and are well executed.

The language is not so full of technical terms as to confuse one whose scientific vocabulary is limited.

The book contains much that is valuable, and is well worth a careful study. C.

Pyramid Metrology.—The series of papers by President Barnard, published in the QUARTERLY, are now issued in book form by John Wiley & Sons. The presentation of the common-sense view of the whole system of Pyramid metrology has been ably made. The references to astronomy, geodesy, metrology, archæology, etc., give much valuable information.

Kunhardt on Ore Dressing.—The QUARTERLY board of Editors have begun to make reprints in book form of the most important long articles which have appeared in the magazine. President Barnard's articles on Pyramid Metrology, and Kunhardt's papers on Ore Dressing will be the first published. This latter work has already been adopted at the School of Mines as a reference book of authority on ore dressing.

GRADUATE DEPARTMENT.

QUARTERLY MEETINGS.—The third quarterly meeting of the Alumni Association was held on May 2, in accordance with the following call and programme :

ASSOCIATION OF THE ALUMNI OF THE SCHOOL OF MINES, COLUMBIA COLLEGE.

NEW YORK, April 20, 1884.

DEAR SIR :

The third quarterly meeting of the Association, for the year 1883–84, will be held at the School of Mines, Columbia College, on Friday, May 2, 1884, at 8 P.M.

The proceedings of special interest will be as follows :

I.—Report of the Committee on the question as to the advisability of adding a Fifth Year to the School of Mines Courses.

II.—Inspection of the new Department of Architecture, the Library, the Observatory, and the Mechanical Assay Laboratory.

The graduating class of the School of Mines, and the Glee Club. will be present by invitation.

An informal collation will be served at about ten o'clock, for which the usual charge of $1 *per capita* will be made.

If you expect to be present, please notify the Committee before May 1.

Yours truly,

J. K. REES,
P. DE P. RICKETTS,
ALFRED L. BEEBE,
} *Standing Committee on Quarterly Meetings.*

Through the kindness of Prof. Ware the new Department of Architecture was thrown open to the graduates. The Observatory and the Mechanical Assay Laboratory were also opened for inspection after the adjournment of the business meeting, the minutes of which we give below. The collation was served in the architectural rooms, where the graduates and the graduating class of the School of Mines met around the festive board and listened to the college Glee Club. The graduating class of the school and the Glee Club were present by special invitation.

The following account of the business portion of the meeting may prove of interest to those graduates who were unable to be present :

Minutes of the Third Quarterly Meeting of the School of Mines Alumni Association for the year 1883–84, held at the School of Mines, May 2, 1884.

The meeting was called to order at 8.35 P.M.

Present about seventy-five graduates and the members of the graduating class of the School of Mines. The President of the Association, Mr. F. Augustus Schermerhorn, occupied the chair.

The minutes of the previous meeting were read and approved.

The Treasurer offered the following report, which was accepted, and the Secretary instructed to place the same on file:

REPORT OF TREASURER.

MAY 2, 1884.

Cash received to date	$849 91
Cash paid out	365 34
Balance on hand	484 57
Due S. of M. QUARTERLY	66 50
Net Balance on hand	$418 07

The Report of the Special Committee appointed at the last meeting to consider the advisability of adding a fifth year to the School of Mines Courses was then called for.

The committee reported through its chairman as follows:

Resolved: That, in the judgment of your committee, it would not be wise at present to increase the course of study of all students to a term of five years, but rather that after a prescribed course of three years for college graduates and four for others, degrees should be conferred as now, while to all such as may desire to pursue further and more special studies, post-graduate courses should be opened, in which one or more years should be passed in well-regulated and specific studies, followed by examinations and the bestowal on the successful candidates of the degree of Ph.D.

It was moved and seconded that the report be accepted and the Committee be discharged with thanks. Amended that the report be tabled —seconded. Motion to table was lost.

Dr. Waller said that the resolutions were recommendatory. The age of those entering should be higher. His age was 22 when he entered. More of his classmates were older than that, rather than younger. Now students enter at 17, sometimes younger. This has had a bad effect. At that age students are not fitted mentally, physically, or morally for taking a professional course. They have not the maturity of mental powers. Physically they can't stand the strain, and morally they don't appreciate what it is to take hold of a professional course. It is hard work and no play. The students want to get through with it as a general education, and continue to attend to society, athletics, &c. When they enter a professional course they should give these things up. They say that the degree at the end of the course will get them everything they want. The degree is what the student wants. The next point is how to get the degree. By marks. They try for that no matter how little is learned. There is a strain for marks and not for conscientious work. The result is cheating in various forms on their part more than I would like to say. The remedy for this is that the age should be increased, and those who come for a professional course should be sufficiently mature in years and mental development to take hold of a professional course as such, and carry it through conscientiously and not as it is carried through now.

Mr. Rees said that the committee evidently hoped that some good would develop from a systematic post-graduate course. It may be, perhaps, wise for the association to recommend that the post-graduate courses in the School of Mines be made more systematic than they are now. It is the tendency in the schools of science and arts, so that

those who wish to proceed further may do so. Dr. Waller's arguments are sound. It would be desirable to have older men and higher acquirements. We can adopt the report of the committee as a whole. I move the adoption of the report.

Mr. Ledoux, on behalf of the committee, said the committee would be unanimous in agreeing with what Dr. Waller and Prof. Rees said, but the committee had to take action about the fifth year only.

The motion that the report be accepted and the committee be discharged with thanks was then carried.

Mr. Elliott moved that the sense of the meeting as to the advisability of adding a fifth year of instruction for the degree of Ph.D. be taken. He did so in order that the matter might be discussed by the meeting.

Mr. Butler said that the Alumni Association is looking toward that relief for the students which they must soon have. If the relief is to come from the outside, it must come by a fifth year, or by increasing the standard of admission or of age. A second method, however, would be by lightening the work in the school in some way. The relief should be gauged by what the graduates are actually doing; by what courses are practically carried out after graduation, favoring these in some way and disfavoring others. The schemes show that certain courses tend to monopolize the time of the students. Comparing the course with what the graduates are actually doing, we see that too much attention is given to certain studies. Internal relief is what I would like to call attention to.

A fifth year would not do any good unless a revolution took place. If a fifth year be added and things go on as now, things will be shoved over and added on as now. The men will be more learned, but they will have studied a year longer. This is the least attractive way of getting rid of the difficulty. The other way is internal relief or a method of increasing the standard of admission.

After some discussion as to the conferring of the degree of Ph.D. at the end of a fifth year, Mr: Sawyer said that after graduating from the School of Mines, men were just fit to take up some special study. That is the thing the extra course should provide for. If it is to be a general fifth year he did not think it would answer. If it were for one or two years, and one could get the degree of Ph.D. for such a course, he thought it would be much better than adding a year for a general course.

Mr. Hale: The real difficulty which the committee has in discussing this subject is its connection with the change of the name of the school. If it be decided to change the name, what we now discuss may be a little "previous."

Mr. Pitkin: The great need we have here in America, and for which we should train our graduates, is the possibility of achieving something original. If we add a fifth year and grant the degree for that, it does not make us rely on ourselves. It should be granted to those who show special aptitude in special departments.

Mr. Ricketts: The motion with respect to the fifth year is without any special reference to any course of studies, although the resolutions mention the degree of Ph.D. The report was accepted, and the question before us is the advisability of a fifth year, and not as to whether it should be general or systematic.

A member of the committee said that the committee did not recom-

mend a specified course for Ph. D., but that the present situation of things should be continued for a time. That no fifth year should be added, but that those who desired to study longer should take the post-graduate course.

Mr. Elliott: I wish to get the sense of the meetfng as to whether the fifth year is to be a systematic one, or whether the present way of conferring the degree of Ph. D. should be continued.

Mr. Beebe said that there is a great diversity of opinion, and as the hour is drawing on apace and there is material for more discussion, he moved as an amendment that the final action be postponed to the next meeting of the association. This amendment was accepted by Mr. Elliott and carried.

Mr. Ricketts said: The question of adding a fifth year suggests a number of other questions. Is the School of Mines to be a special school for professional instruction to turn out men fitted for places in works, or in connection with mines or establishments of a professional nature; or is it intended simply as a scientific school to give the young men a general scientific education? The students, at present, are driven with studies more than they can properly attend to; are overcrowded, and there is a tendency, on account of this overcrowding, to get through the examinations in some way rather than fail. The student intends to pass the examination honestly if he can.

How can we relieve this pressure? By raising the standard as to age and studies? Are the preparatory schools sufficiently advanced? Do they teach the studies required? The next question is, If the standard is not raised, can we add this fifth year in a special or a general way? If that can't be done, can we divide up the course and systematize the work? All these questions are important and should be answered.

Mr. Sawyer moved that a committee be appointed to discuss the various methods of relief and report at the next meeting. Seconded.

Mr. Butler thought that the graduates should communicate with the committee; and suggested that the graduates be invited to communicate their views in writing to the committee.

It was moved by Mr. Kunhardt as an amendment that the original committee of five be continued with power to enlarge to ten. The motion as amended was carried. Moved and seconded that the treasurer be empowered to pay any bills that the committee contract, such as for sending circulars to the graduates, &c. Carried.

Prof. Rees then stated that as the association might feel interested in the QUARTERLY, he therefore presented the following report as to the condition of that magazine.

SUBSCRIPTIONS.

Graduates, about	250
Undergraduates	125
Outsiders	25
Total subscribers	400

EXCHANGES.

Some fifty valued at about $250. The expectations of the board are that this department will improve and the number of the exchanges increase.

REPRINTS.

Prof. Rees stated that the following were in preparation :

The Metrological System of the Great Pyramid, by Dr. Barnard.
Ore Dressing in Europe, by W. B. Kunhardt.
Ore Deposits, by Prof. J. S. Newberry.
Chlorination Mill, by F. D. Browning.

Reading from the report of the treasurer of the QUARTERLY, Prof. Rees stated that the financial condition of the QUARTERLY was about as follows :

Total of subscriptions paid in and cash received from sales..	$504 00
Total received from advertisements	379 50
Total cash received	$883 50
Paid out for sundries for Vol. IV	$102 26
Paid out for sundries for Vol. V	46 62
Total amount paid	$148 88

ASSETS OF THE QUARTERLY.

Balance of cash on hand	$734 62
Due for advertisements	227 50
Due from subscribers	55 00
Due from the Alumni Association	66 50
Promised donation	100 00
Total assets	$1,183 62

The cost of the numbers for the year 1883 and 1884 was about as follows :

November number	$300 58
January number	265 24
March number	260 24
May number, about	275 00
Total	$1,101 06

There is still due Messrs. John Wiley & Sons $154, which added to the cost of the numbers makes a total of $1,255.06. This leaves the Quarterly Board in debt, which would not be the case had there not remained an indebtedness of over $100 left by the old Board. The QUARTERLY has steadily increased in importance and size, and in order that the expenses of publication may be met it is hoped that the magazine will receive from graduates increased support.

On motion, the report was accepted.

Mr. Beebe stated that the Quarterly Board were short of professional notes, and urged the graduates to send these in, the notes from journals not having the same value as original matter.

The Secretary stated that the following gentlemen had been elected as honorary and associate members of the Association, and had notified him of their acceptance :

HONORARY MEMBERS.—Hon. Hamilton Fish ; G. M. Ogden ; Dr. C. R. Agnew ; Lewis M. Rutherford ; George M. Miller.

ASSOCIATE MEMBERS.—Henry D. Brewster ; Carl Barus ; Dr. J. H. Brower Browning ; Edward W. Martin.

Moved and seconded that the meeting adjourn to partake of the collation provided by the committee. Carried.

WESTERN BRANCH.—The following communication from graduates of the school located in the West may prove of interest:

TO THE ALUMNI ASSOCIATION OF THE SCHOOL OF MINES.

At a meeting held at Denver, Colorado, April 3, 1884, we, the graduates of the Columbia School of Mines, voted it expedient to establish a Western Branch of the Alumni Association at Denver. We request the Secretary of the Association to notify the graduates in the West that a meeting will be held at Denver on or about July 1, 1884, to take action toward the establishment of such a branch.

We hereby subscribe our names, trusting that the Association will give this matter its immediate attention.

Signed: H. W. LFAVENS, '75, BENJ. B. LAWRENCE, '78,
MALVERN W. ILES, '75, H. VAN F. FURMAN, '81.

As stated in a previous number, the matter of establishing a Western Office of the Association has already received the attention of the Board of Managers, and has been referred to the Committee on Constitution and By-Laws. The following is the report of the Committee on the proposed amendments to the Constitution, which include a plan for the establishment of a Western Office.

COLUMBIA COLLEGE, NEW YORK, Apr. 22, 1884.

The following proposed amendments to the Constitution of the Association of the Alumni of the School of Mines, are transmitted to the members of the Board of Managers, in compliance with a resolution passed at a Special Meeting of the Board held April 15, 1884.

ARTICLE III.

MEETINGS.

SECTION 1.—Meetings shall be held, at least, four times during each year, for the reading of papers and the discussion of subjects of general or of professional interest, and for social intercourse. Three of these meetings shall be held in the city of New York in the months of May, October, and December, and one in the city of Denver in the month of July; unless otherwise ordered by the Board of Managers.

SECTION 2.—The Annual Meeting of the Association shall be held in the city of New York in the last week of December, the day and place of meeting each year to be fixed by the Board of Managers.

ARTICLE IV.

OFFICERS.

SECTION 1.—The officers of this Association shall be a President, three Vice-Presidents, a Treasurer, a Secretary, and an Assistant Secretary.

SECTION 2.—The President, Second Vice-President, Treasurer, and Secretary shall be residents of New York City or vicinity. The First and Third Vice-Presidents and the Assistant Secretary shall be residents of Denver or vicinity, and shall constitute an Executive Committee of the Board of Managers for the territory west of the Mississippi.

ARTICLE VI.

TREASURER.

SECTION 1.—It shall be the duty of the Treasurer to collect all money and pay all bills of the Association; but no indebtedness shall be incurred unless previously authorized by the Board of Managers. No bills shall be paid unless previously indorsed by the Secretary. The Treasurer shall present to the Board, etc., etc.

ARTICLE IX.

ELECTIONS.

SECTION 1.—The Board of Managers shall be elected as follows: The Secretary shall mail to each member, at least three months before the Annual Meeting, a list of the regular members, etc., etc.

These ballots must be opened and counted one month before the Annual Meeting, etc., etc.

SECTION 2.—The officers of the Association shall be elected by the Board of Managers, in a manner similar to that provided for the election of the Board of Managers in Section 1 of this Article. The ballots must be opened and counted at a meeting of the Board to be held immediately before the Annual Meeting.

SECTION 3.—John Magnus Adams, the first graduate of the School of Mines, shall be a life member of the Board of Managers.

A. W. HALE,
F. R. HUTTON,
A. L. BEEBE,
} *Standing Committee on Constitution and By-Laws.*

These amendments will come before the Board of Managers at their next meeting the latter part of this month, and should it be impossible to carry out the plan given at once, a committee will undoubtedly be appointed to start a Western Office preparatory to the establishment of the same on a permanent basis.

SPECIAL NOTES.

Among the changes of address we note that of Hermann Hollerith, Class of '79. We are glad to see that Mr. Hollerith has taken hold of the line of professional work indicated, viz., Solicitor of Patents, and heartily wish him success. He certainly has had a thorough course of training for the work in his connection with the U. S. Patent Office.

We understand that Mr. F. T. Aschman of the Class of '81 has opened an analytical laboratory at Sharon, Penn., where he has been for some time as chemist for the Wheeler Iron Co.

We regret to learn of the death of Mr. Anton Fernekes, Class of '78, on March 13, 1884. Mr. Fernekes had been a resident of Denver for some time, but we understand died in Milwaukee, Wis.

CHANGES OF ADDRESS.

1867.—Chas. King Gracie, E.M., 37 New Street, New York City.
A. W. Hale, E.M., No. 1 Broadway, Room 206, New York City.
Kenneth Robertson, E.M., Secaucus Iron Co., Secaucus, N. J.
1871.—R. S. Robertson, E.M., Jackson, Minn.
1874.—W. de L. Benedict, E.M., Benedict & Cole, 32 Liberty Street, New York City.
Geo. Murray, E.M., Superintendent Horn Silver Smelting Works, Franklin, Utah.
1876.—Fred E. Bruen, E.M., Superintendent Col. Sellers' Mine. Address P. O. Box 16, Leadville, Colorado.
1877.—S. A. Reed, E.M., Pueblo Ore Sampling Co., South Pueblo, Colorado.
1878.—W. B. Devereux, E.M., Aspen, Colorado.

1878.—Benj. B. Lawrence, E.M., Montezuma, Summit Co., Colorado.
Wm. Hollis, C.E., P. O. Box 109, Eagle Pass, Texas.
Richard A. Parker, C.E., Atlanta, Alturas Co., Idaho Terr.
1879.—Herman Hollerith, E.M., P. O. Box 225, Washington, D. C.
Knight Neftel, C.E., The Yale & Towne Mfg. Co., 62 Reade Street, New York City.
R. D. Rhodes, E.M., Box 211, Socorro, New Mexico.
1880.—Andrew McClean Parker, E.M., 59 & 61 Wall Street, New York City.
1881.—F. T. Aschman, Ph.B., Lock Box 81, Sharon, Mercer Co., Penn.
H. Van F. Furman, E.M., 137 W. 34th Street, New York City.
Clement Le Boutillier, Ph.B., Care of Cambria Iron Co., Johnstown, Penn.
Percy Neymann, Ph.D., Care of Sherwin, Williams & Co., 100 Canal Street, Cleveland, Ohio.
Edward G. Tuttle, E.M., 259 Carlton Ave., Brooklyn, N. Y.
1882.—Henry Feuchtwanger, Ph.B., Care of M. Feuchtwanger & Co., 73 Leonard Street, New York City.
W. S. White, E.M., Room 33, No. 39 Nassau Street, New York City.
Edward L. Young, E.M., N. Y. Milling and Ore Testing Works, 528 West 16th St., New York City.
1883.—J. J. MacTeague, E.M., Assayer, Billings Smelting Works, Socorro, New Mexico.
J. G. Oxnard, Ph.B., 155 Warren Street, Brooklyn, L. I.
G. A. Suter, E.M., with Exhaust Ventilator Co., 45 Fulton St., New York City.
W. H. Weed, E.M., U. S. Geological Survey, Museum of Natural History, Central Park, New York City.

Graduates are requested to keep the Secretary posted as to any changes of address, so that the necessary corrections in the association list can be made.

P. DE P. RICKETTS,
Secretary School of Mines Alumni Association.

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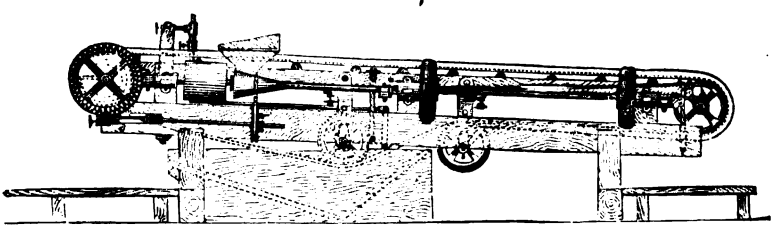

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